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DELL'S EXCELLENT XPS 13 ULTRABOOK GETS SLEEKER & FASTER WITH A NEW 2018 EDITION

apc
Apr 2018
Issue 453
YOUR EX

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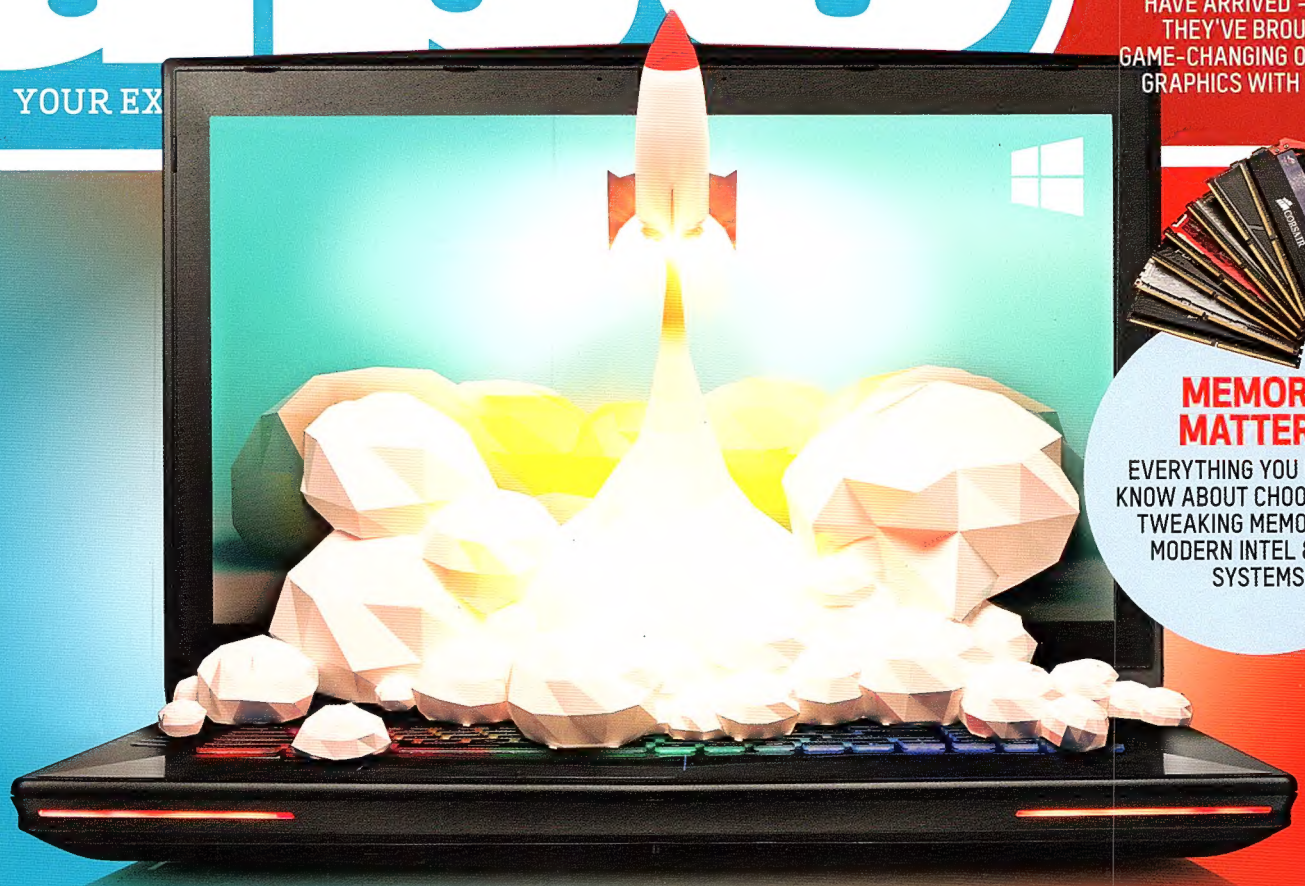
SECOND-GEN RYZEN CPUS HAVE ARRIVED — AND THEY'VE BROUGHT GAME-CHANGING ONBOARD GRAPHICS WITH THEM!



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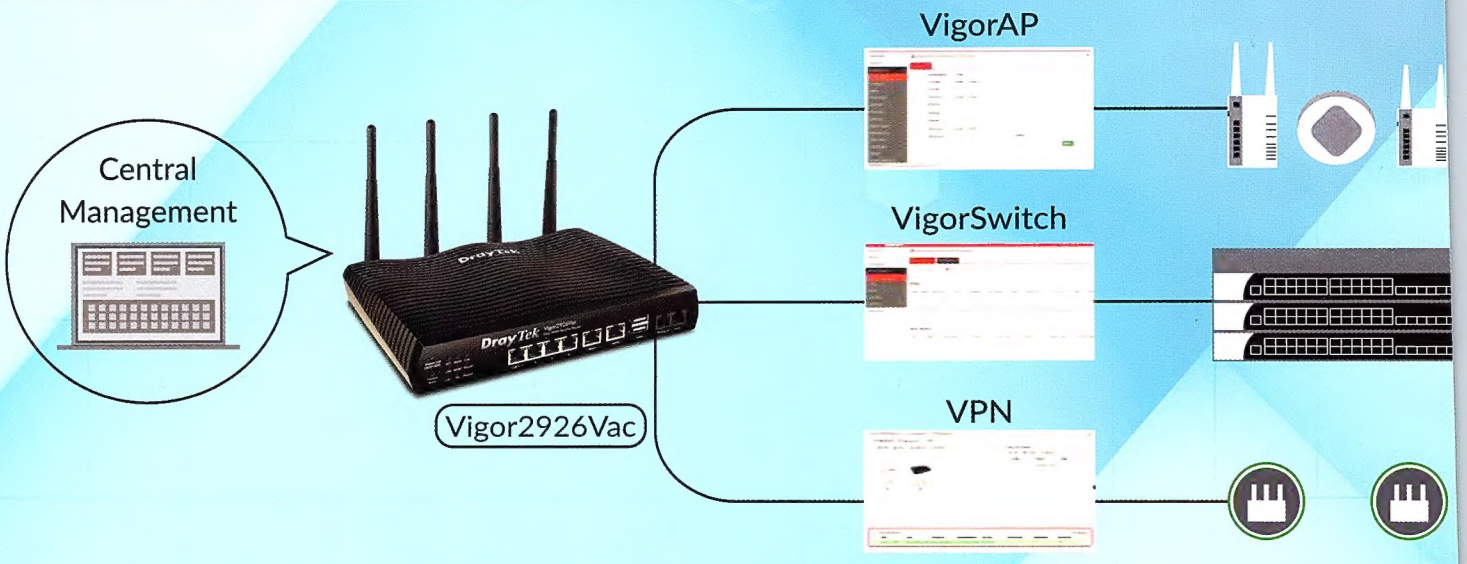

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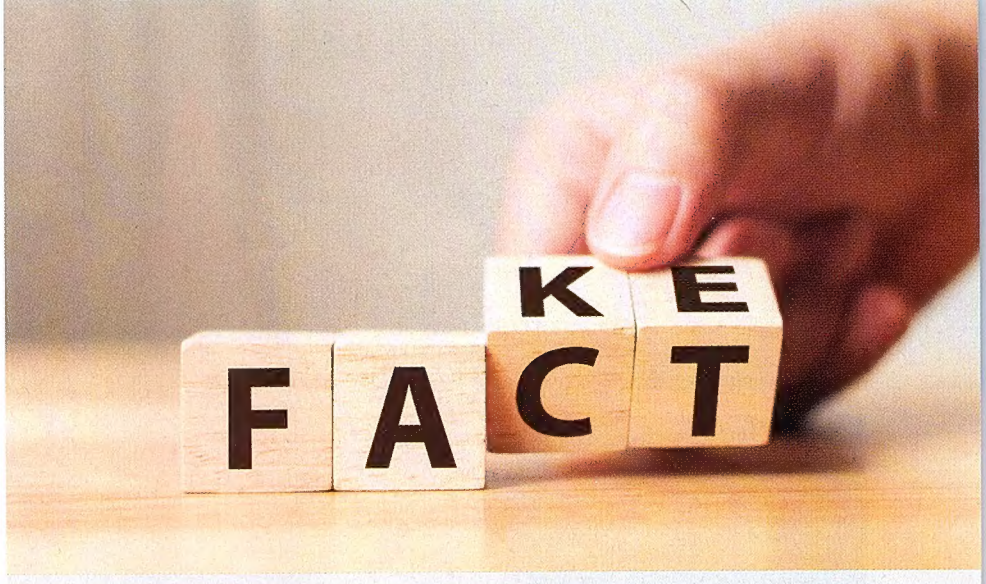

When it comes to fake news, we are the weakest link

A new study of 126,000 tweets has found that its not just bots that love fake news.

Since the UK's surprise vote in favour of Brexit in June 2016 and, a few months later, the similarly unexpected election of Donald Trump in the US, there's been much ink spent on poring over what social media is doing to our democracy. Rather than bringing people together (which Facebook founder Mark Zuckerberg has espoused is his company's main goal) social media is seemingly even more adept at finding and exacerbating the fault lines in our democracies' internal points of disagreement, and in demonising either side of the debate and, therefore, making finding a 'middle way' even more difficult.

That inherent capability has been exploited and 'weaponised' by Russia in an information war against the West, using tactics it first developed after it controversially annexed the Ukraine in 2014 – something that all of the major US intelligence agencies (the CIA, FBI and NSA) and social-media companies are in agreement on.

'Divide and conquer' is a strategy that humans have been using against each other for thousands of years, where creating internal dissent destabilises your enemy and makes them unable to deal with outside threats.

HOW TO SPOT FAKE NEWS

The proliferation of fake news is a development that almost makes you want to swear off social media entirely – and though I like to think Aussies are a generally congenial bunch who get along well with each other, there's little doubt that the tactics used by Russia in the US and UK could also be employed here.

I believe the key to fighting this information war is education – specifically, understanding what fake news is and why it's effective. A study recently conducted by MIT using 126,000 tweets spanning 10 years has discovered that fake news is crafted to generate an emotional response – something which prompts people to share that story much further and faster. If something in your Facebook or Twitter feed promotes an instant and strong emotional response, chances are good it's been crafted to do just that... and is probably also bullshit. 'Think before you share' is probably the best defence against the negative effects of fake news, but knowing how and why it's created can also be an immense help. For the latter, I'd suggest checking out Bad News, a cheeky online game at **getbadnews.com** that teaches you how to craft fake news and should, therefore, help inoculate you against it. ■

DAN GARDINER
EDITOR-IN-CHIEF
dan.gardiner@futurenet.com

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"Try to imagine it's a reasonable build, that parts are priced fairly, that there isn't a hardware shortage, and that everything is right in the world."
PC Builder Masterclass, page 92

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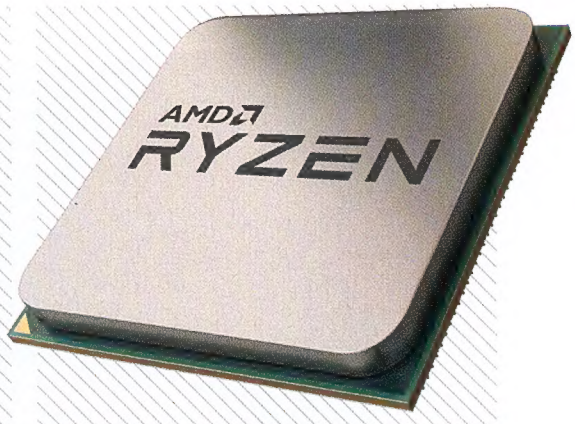

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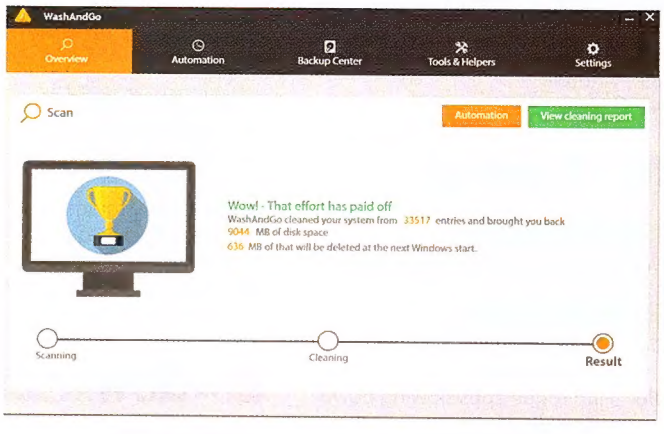

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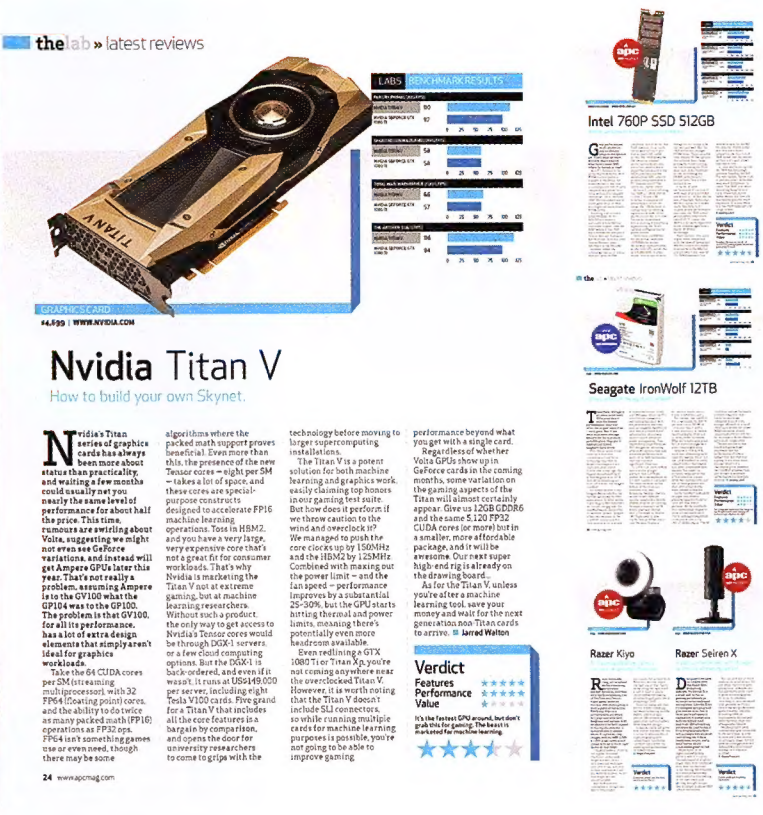
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Nvidia Titan V
How to build your own Skynet.
Nvidia's Titan series of graphics cards has always been more about status than practicality, and waiting a few months could usually net you nearly the same level of performance for about half the price. This time, rumours are swirling about Volta, suggesting we might not even see GeForce variations, and instead will get Ampere GPUs later this year. That's not really a problem, assuming Ampere is to the GV100 what the GP104 was to the GP100. The problem is that GV100, for all its performance, has a lot of extra design elements that simply aren't ideal for graphics workloads.
Take the 64 CUDA cores per SM (streaming multiprocessor), with 32 FP64 (floating point) cores, and the ability to do twice as many packed math (FP16) operations as FP32 ops. FP64 isn't something games use or even need, though there may be some
algorithms where the packed math support proves beneficial. Even more than this, the presence of the new Tensor cores – eight per SM – takes a lot of space, and these cores are special-purpose constructs designed to accelerate FP16 machine learning operations. Toss in HBM2, and you have a very large, very expensive core that's not a great fit for consumer workloads. That's why Nvidia is marketing the Titan V not at extreme gaming, but at machine learning researchers. Without such a product, the only way to get access to Nvidia's Tensor cores would be through DGX-1 servers, or a few cloud computing options. But the DGX-1 is back-ordered, and even if it wasn't, it runs at US$149,000 per server, including eight Tesla V100 cards. Five grand for a Titan V that includes all the core features is a bargain by comparison, and opens the door for university researchers to come to grips with the technology before moving to larger supercomputing installations.
The Titan V is a potent solution for both machine learning and graphics work, easily claiming top honors in our gaming test suite. But how does it perform if we throw caution to the wind and overclock it? We managed to push the core clocks up by 150MHz and the HBM2 by 125MHz. Combined with maxing out the power limit – and the fan speed – performance improves by a substantial 25–30%, but the GPU starts hitting thermal and power limits, meaning there's potentially even more headroom available.
Even redlining a GTX 1080 Ti or Titan Xp, you're not coming anywhere near the overclocked Titan V. However, it is worth noting that the Titan V doesn't include SLI connectors, so while running multiple cards for machine learning purposes is possible, you're not going to be able to improve gaming performance beyond what you get with a single card.
Regardless of whether Volta GPUs show up in GeForce cards in the coming months, some variation on the gaming aspects of the Titan will almost certainly appear. Give us 12GB GDDR6 and the same 5,120 FP32 CUDA cores (or more) but in a smaller, more affordable package, and it will be awesome. Our next super high-end rig is already on the drawing board...
As for the Titan V, unless you're after a machine learning tool, save your money and wait for the next generation non-Titan cards to arrive. ■ Jarred Walton
Verdict
Features
Performance
Value
It's the fastest GPU around, but don't grab this for gaming. The beast is marketed for machine learning.
24 www.apcmag.com
Intel 760P SSD 512GB
Seagate IronWolf 12TB
Razer Kiyo
Razer Seiren X

Inside APC

Find out all about *APC*'s editorial policies, test practices, how to read the benchmark results and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for over 35 years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer – it's in our name, after all – the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech too, from smartphones and apps to peripherals, accessories, online services and beyond. We have two main goals: to track down the best of modern tech and also to help our readers make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And like you, *APC*'s journalists want to know what's good in tech – no matter what platform it resides on.

INDEPENDENT REVIEWS

Championing technology doesn't mean we're unrelenting yes-men, however, and *APC* aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three.

As a matter of policy, reviews published in *APC* are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an *APC* reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

LABS TESTING

Despite being a small magazine with limited resources, *APC* still still strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance, gaming and battery life.

In most cases, for the benchmark results published in *APC*, you can assume that higher is better. There are certain tests that deviate from this rule and where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter are our preference due to their ease-of-readability, but tables are more compact, so we use these in cases where thoroughness is preferred.

technotes

» NEED TO KNOW

It's no hoax: Nokia and Vodafone are putting 4G on the Moon

THE ROAMING CHARGES WILL BE ASTRONOMICAL.

The Moon will get its first 4G setup in 2019, thanks to Vodafone Germany and Nokia. The Moon's data network will be used to support Berlin-based space exploration company PTScientists in studying the satellite's surface via two lunar rovers that car manufacturer Audi is producing. Nokia Bell Labs will create a space-grade "ultra compact network" for Vodafone's base station that won't weigh more than "a bag of sugar", with the mission scheduled to launch in 2019 from Cape Canaveral, Florida, on a SpaceX Falcon 9. **SS**

New Zealand government sued by Kim Dotcom

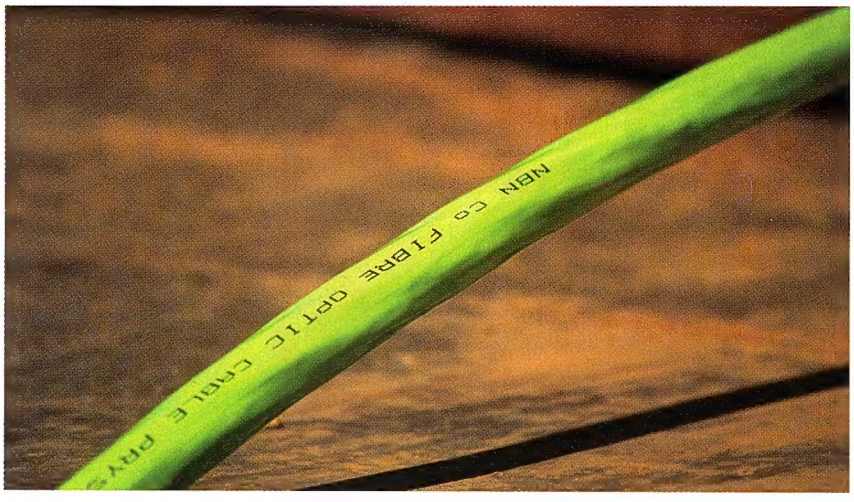
KIWI AUTHORITIES ACCUSED OF NEGLIGENCE AND MISFEASANCE.

Six years after NZ authorities conducted military-style raids to arrest individuals accused of copyright infringement, Kim Dotcom is suing the government for billions of dollars. The German-born entrepreneur has always maintained that his arrest was unlawful under New Zealand law. That arrest, he says, resulted in "the unlawful destruction" of his now-defunct file hosting service Megaupload. The legal documents filed in court claim the arrest warrant was invalid and there were no reasonable grounds for Dotcom to lose his freedom and his profitable company. **SS**

Australian, US and UK govs blame Russia for NotPetya virus

RUSSIA DENIES ALLEGATIONS.

Halfway through 2017, malware NotPetya swept the globe, crippling governmental and business computers and halting operations in hospitals, ports and many other major sectors. Now, the finger has been pointed at Moscow, more specifically at its military, as AU joins the UK and US claiming the attack was more than just criminal activity but a militaristic disruption. **HD**



Wholesale NBN discounts extended, but HFC still in limbo

...and kiss the 25Mbps speed tier goodbye.

NBN Co is trying to standardise the 50Mbps speed tier instead, promoting it in a campaign called "Focus on 50". The promotion, which saw the wholesale price of the 50Mbps drop with an additional 50% extra bandwidth offered for free to the service providers (ISP/RSP). The promotion was due to end in April 2018, but the national broadband service has announced that the promotional period will be extended 'til October to enable RSPs to prepare for the switch to a permanent price once the promotion has ended. In a bid to get more end users on the higher speed plans, some resellers, like TPG, have dropped the 25Mbps plans altogether. Telstra is also upgrading all its customers on the slow plan to the 50Mbps tier for free.

While NBN tries to push its high-speed plans onto the end user on fibre, millions expecting to connect to Hybrid Fibre Coaxial (HFC) broadband are still waiting. Citing performance issues, NBN Co decided to halt the rollout of its HFC connections in December 2017, saying it would be delayed by six to nine months, with updates available in February 2018. February has come and gone, and the rollout is seeing further delays. The only information forthcoming on the status of the HFC rollout from the NBN is "new information will be available over the coming weeks". **Sharmishta Sarkar**

Australians put at risk by lack of NBN speed guarantees, says ACCAN

SUGGESTS NEW STANDARDS BE DRAWN.

In a submission made to the ACCC inquiry into NBN wholesale service standards, consumer-advocate group the Australian Communications Consumer Action Network (ACCAN) says that Australian consumers haven't been provided with adequate rights when it comes to ensuring the reliability and quality of NBN broadband services, with the organisation claiming that the current system is effectively a monopoly — and one which comes with insufficient guarantees.

"While consumers may have some success asserting their rights at the retail level under contract or the Australian Consumer Law, this is much more complicated at the wholesale level," said the ACCAN, further suggesting that, "improved consumer protections policy is required."

The ACCC launched an inquiry last November to determine whether NBN wholesale service standards are appropriate, and to consider whether regulation is necessary to improve customer experiences. **Stephen Lambrechts**

Every Oculus Rift VR headset rendered inoperable

Devs accidentally let web certificate expire.

Oculus Rift users who logged into their computers on March 7th, 2018, for some virtual reality shenanigans were met instead with a dialogue box warning of a runtime error. Turns out, devs at Oculus VR had forgotten to renew a crucial app permission within its Oculus Runtime Service for Windows 10 PCs. Users from around the world cited the problem on the Oculus VR forum in a thread that was six pages long at the time of writing. As one Oculus VR forum user put it, "Someone has neglected his responsibility... now we have to wait and mess around with Windows clock... a simple message from Oculus on this yesterday would have been so nice."

Oculus VR, however, released a statement on the same forum, saying, "We are aware of and actively investigating an issue impacting ability to access Rift software. Our teams apologize for any inconvenience this may be causing you and appreciate your patience while we work on a resolution. We'll share more updates here as we have them. Thanks."

Sharmishta Sarkar

NSW Government has no "capability to detect and respond effectively to cyber security incidents"

REPORT PAINTS A GRIM PICTURE OF STATE SECURITY.

In a recently released report from the NSW Audit Office, the Auditor-General went to town on the State Government for its apparent incapacity to handle, or even discover, cyber security risks. "There is limited sharing of information on incidents amongst agencies," the report surmised, "and there is a risk that incidents will go undetected longer than they should. Given current weaknesses, the NSW public sector's ability to detect and respond to incidents needs to improve significantly and quickly."

While 10 of the State Government's agencies were targeted during this audit, they were all noted as being departments that should have the strongest of security capabilities due to their responsibility in handling "personal data, critical infrastructure and intellectual property". Despite this, only two of them were found to have adequate protections and procedures, while the other eight's low scores were deemed a threat.

To its credit, the NSW Government has officially acknowledged the need for action in its response, promising to implement the recommendations made and ensure its systems are protected and resilient in the digital age. **Harry Domanski**

Telstra upgrades all 25Mbps NBN customers for free

DOUBLES DOWNLOAD SPEEDS AND INTRODUCES NEW MODEM WITH 4G BACKUP 'NET.

Over 850,000 existing users on Telstra's NBN 25 plan (25Mbps/5Mbps) will have their service automatically upgraded over the coming months to the NBN 50 plan (50Mbps/20Mbps), as the company begins to offer 50Mbps plans as its new mainstream services. The telco has also announced that customers signing up to new NBN home or business bundles will receive its new modem, which features an always-on 4G service as a backup in case of an NBN connection problem. **HD**

Modders get Intel 8th-gen chips working on 'incompatible' motherboards

YOU CAN DO IT TOO, BUT IT'S NOT EASY.

Despite Intel's official line on the latest Coffee Lake chips not working with older Z170 and Z270 motherboards due to power requirements, some modders have found a way. A recent forum post on **overclock.net** details the rather involved methods of achieving this, but according to PC Gamer, "the modders were able to get a Core i3-8300 processor to boot, but not a Core i7-8700 chip ... suggesting that the power issue is related to driving higher core counts". **HD**

Mozilla tries to clean up IoT with the launch of Project Thing

CLEANING UP THE THINGS.

Mozilla has launched a new project to enable everyone to control all their 'smart' IoT devices. Project Thing has been assembled for the Raspberry Pi. The software (called the Things Gateway) bridges existing IoT devices and your smartphone, using the Raspberry Pi as a gateway. Currently, many of these sorts of devices are designed to pipe commands via proprietary hubs, with all the problems that brings. Project Things aims to standardise these web technologies into a single open standard. **LP**

numbercrunch

» HARRY DOMANSKI LOOKS AT THE NUMBERS DRIVING THE BIG TECH NEWS

THE LENGTH OF AN EU-SUPPRESSED STUDY THAT FOUND THERE TO BE NO EVIDENCE OF PIRACY HARMING SALES

After spending €360,000 ($565,750) on a 2015 study that investigated the impacts of piracy on the sale of copyrighted movies, video games, music and books, the European Commission apparently never shared the 304-page document or its findings. Almost three years after it was originally submitted, that report has now been legally obtained from the EU by a member of the German Pirate Party. Among its other findings, it clearly states that "the results do not show robust statistical evidence of displacement of sales by online copyright infringements".

1.53Mbps

AVERAGE BANDWIDTH PER NBN USER CLIMBS AFTER DISCOUNTED RATES COAX ISPS TO BUY UP

After NBN Co discounted its Connectivity Virtual Circuit (CVC) rates in September 2017, allowing ISPs to purchase more bandwidth at a reduced cost, the average bandwidth per user has since climbed by 38% up to 1.53Mbps. That might not seem like much, but NBN Co does claim that it's already resulted in a reduction in peak-hour congestion — "from six or seven hours average a week, to less than 30 minutes", according to CEO Bill Morrow. So... better than a kick in the fibre pot, we 'spose?

1 in 3

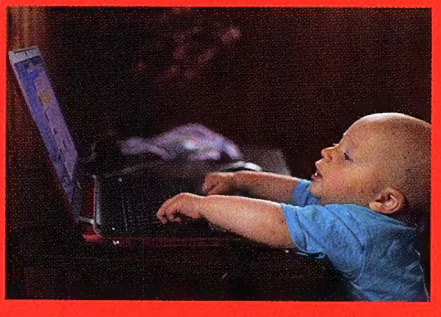
NUMBER OF AUSTRALIAN ADULTS THAT WERE VICTIMS OF CYBERCRIME IN 2017

Over the course of 2017, digital security firm Norton believes that one in three Australians were the victim of cybercrime — a definition which it applies to actions such as identity theft, credit card fraud, or account compromisation. This cost Aussies an estimated $2.3 billion, but despite this, 29% of the surveyed victims "had a higher trust in their own ability to protect their data and personal information from future attacks".

$454

GLOBAL AVERAGE PRICE PAID FOR A SMARTPHONE IN 2017

The average price that people pay for their smartphone has been in decline for several years, largely due to the introduction of competition to the iPhone, but the numbers have risen again throughout 2017 and are now the highest they've been since 2012. Global market research company Growth from Knowledge has taken customer checkout data from around the world and found that consumers pay an average of $454 for a new smartphone.



2.8 million

NUMBER OF U.S. USERS UNDER THE AGE OF 25 THAT FACEBOOK LOST IN 2017

Despite the stereotype of today's youth being a rather social-media-obsessed bunch, according to market research firm eMarketer, in the US, Facebook actually lost 2.8 million users under the age of 25 last year. While the firm had predicted a decline in this demographic's userbase, the actual results were roughly three times more severe than they'd originally anticipated. Unfortunately for Facebook, eMarketer predicts much the same thing will happen again in 2018, with a 2.1 million user decline in the under-25 age group — the first year-on-year decline the analysis company has ever predicted for this younger segment. ■

techbrief

» CARMEL SEALEY WADES INTO A CURRENT NEWS TOPIC TO TAKE A CLOSER LOOK

You get a cryptocurrency, and *you* get a cryptocurrency...

A warning look at all the stupid, scammy and joke cryptocurrencies that are hoping to cash in on the craze.

Unless you've been on a serious technology detox holiday for the past couple of years, you'd have heard cryptocurrencies. The simple idea behind these is that they're encrypted, digital-only currencies completely separate to the centralised banks. Rather than relying on big corporations to keep your dollars safe, your cryptocurrency wealth is insured by the blockchain – an open system of distributed databases that tracks and maintains the integrity of every transaction. Such is the popularity of these cryptocurrencies of late that it seems as though every man and his dog are creating their own version. For example....

KODAKCoin

Kodak is hoping its cryptocurrency KODAKCoin will take off and save the company from obscurity. Still in the 'initial coin offering' or ICO crowdfunding phase, this altcoin is designed to help photographers license out their images and intellectual property through the Ethereum blockchain. As a result of the announcement of KODAKCoin at CES this year, Kodak's stock price tripled over just two days.

Atari Token

Atari's current owners are attempting to reinvigorate interest by introducing the Atari Token. Claiming that its new management has brought Atari from the brink of destruction, the company is now bragging of a 60% rise in share prices since announcing the Token. According to a press release, Atari is hoping to "take strategic positions with a limited cash risk, in order to optimise the assets and the Atari brand." Well, it's better than their Speakerhat, we suppose...

Jesus Coin

Yes, you did read that right. This joke altcoin (which proudly admits to be worth nothing) was created to satirise the booming cryptocurrency market, particularly other currencies springing up that sound ridiculous but claim to be legitimate. As a case in point, there's the similar-sounding Christ Coin — a cryptocurrency set up to "financially reward people who read the Bible" and post content on their online community platform. According to Christ Coin's website, these rewards aren't limited to Christians, but are available to all faiths... presumably, that's all faiths willing to read the Bible. ■

Bitcoiin 2Gen

Steven Seagal is probably best known for his '90s action movies. More recently, he's been promoting Bitcoiin (not Bitcoin) as the altcoin's brand ambassador or, according to the press release, 'Zen Master'. Based on the Ethereum blockchain, this cryptocurrency is hoping to soft launch with a value of US$75 million towards the end of March. At the time of writing, they claimed to have already raised more than half that.

Dogecoin

Quite a few immensely popular things around today started as a joke. Take the SmartBoy attachment for iPhone, emulating the feel of a Nintendo Game Boy, for instance. Dogecoin is an altcoin borrowing the likeness of the popular Doge meme and, like Jesus Coin, started off in 2013 as a joke currency. However, as its popularity grew, the currency began to be taken somewhat seriously, and by January this year, its total worth had risen to more than US$1.5 billion. Much excite.

gadgets

» GEAR WE WANT

MYCROFT MARK II

The first loyal smart speaker that won't compile an advertising profile.

US$129 | MYCROFT.AI

For anyone who's against the modus operandi of modern tech companies like Google and Facebook – who mine and sell details of your online activity so advertisers can more precisely target you – today's smart speakers are likely going to pose a bit of a problem. The Mycroft team hopes to bring anyone who values their privacy more than convenience into the smart-speaker fold with its latest open-source AI assisted speaker, simply called the Mark II. It's a little less broad in its overall feature set than the leading Google Home and Amazon Echo smart speakers, but the Mark II improves on its predecessor by adding a 4-inch LCD touchscreen and better speakers to the continued auto erasing query log and data transparency guarantee that the original Mark is known for. **JB**

POCKET SPRITE

Your key to retro gaming.

US$55 | POCKETSPRITE.COM

While the smartphone generation might be fine with touchscreens, many of us 'older' gamers harbour a nagging nostalgia for playing games on a device with actual physical buttons like, say, the Game Boys of yore. Time has not been kind to what was once considered the ultimate incarnation of portable gaming, however, and these days, the ordeal of carrying around a bigger-than-your-smartphone Gameboy will be far more burdensome, for most, than the pure 8-bit bliss it provides. Keenly aware of the fickleness of modern techies, the crowdfunding campaign for the Pocket Spire is spruiking this keychain-sized rig that collects the best games of the Game Boy era and distills them in an extremely concentrated form factor. Now, if only we had Trump-sized hands to play it with... **JB**

YAW VR COMPACT PORTABLE MOTION SIMULATOR

Add three degrees of freedom to your VR setup.

$1,190 | WWW.YAWVR.COM

One of the main things still lacking in today's VR experiences is a physical feedback system – something that can help simulate the feel of moving while you're in that virtual world. We've seen a couple of prototypes for commercial VR treadmills, but a new Kickstarter is taking on the ambitious task of bringing a rotating and rolling seat to home VR setups. It's set to cost about twice as much as a new headset, but this surprisingly compact acceleration simulator seems to be exceptionally responsive and could add a whole other dimension to playing driving and flying games in VR. If that wasn't enough, it's compatible with all the major VR platforms and a range of popular driving games, to boot. **JB**

AZIO RETRO CLASSIC BT

The keyboard for Corvo?

US$220 | AZIOCORP.COM

Looking like it's fallen through a portal from a steampunk alternative universe, this keyboard gives you solid typewriter-style keys with a clicky mechanical action to use with your desktop, tablet or anything else over Bluetooth (a wired version is also available). It's default key config is meant for Windows users, but it also comes with optional Mac-focused keys in the box (you have to pop them on yourself), and is available in copper and black leather, black on black, copper on white, and black and wood finishes. The keys are backlit, and the big 6,000mAh battery should keep it juiced for a long time.

RADINN G2X

The motorised surfboard for techie beach bums.

€9,900 (AROUND $15,700) | RADINN.COM

Do you love the idea of heading to the coast with a surfboard at your side, but aren't actually any good? The Radinn G2X is a surfboard powered by an electric motor, allowing you to skim along the sea in silence, without actually having to learn how to surf. With a 3,800-watt motor strapped to the G2X, you get to surf for 25 minutes at full speed – a not-inconsiderable 50km/hr (an optional bigger battery is available, lasting 35 minutes). Batteries can be hot-swapped in seconds, giving you all-day surfing capabilities, while a 'Radical' upgrade boosts your top speed to 58km/hr, so you can give those pesky, noisy jet skis a run for their money.
Yes, it's a little on the steep side for what is essentially a plastic panel with a motor strapped to it, but just think about how much time you can spend posing while scoffing at the 'real' surfers as they fight the waves.
You can adjust the speed of the G2X by using the handheld wireless controller. It also displays the current battery level and, cleverly, it'll vibrate when the charge gets low, so you (hopefully) don't get stranded at sea!

SENNHEISER RS 185

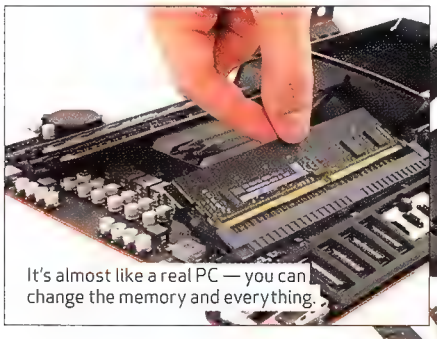
Listen to the sound of my big, bassy cans.

$600 | SENNHEISER.COM

Plug your TV into the RS 185's stand and it will send uncompressed audio out to the high-end, open-backed headphones over a 100m range. They're especially good for audiophiles, thanks to built-in level and balance controls, but Sennheiser's attention to audio detail makes movies and TV sound glorious too. Being open-backed means you'll get an especially wide sound, but audio will leak. That's perfect for dramatic soundscapes, but maybe save it for a living-room TV session when you don't want to wake up the kids, rather than in bed next to somebody sleeping. ■

howit'sdone

Unfortunately, the SSDs still use a proprietary connection standard.


It's almost like a real PC — you can change the memory and everything.

Apple iMac Pro (2017)

You'll actually need to be a bit of a pro to get inside this one...

We dropped $7,299 to get our hands on the hot new space-gray Magic Mouse and Magic Keyboard — and Apple was generous enough to throw in a brand-new iMac Pro for no extra charge! Let's take it apart and see what makes it tick.

MAJOR TECH SPECS

- Eight-core, 3.2GHz Intel Xeon W processor, with Turbo Boost up to 4.2GHz
- 32GB (4 x 8GB) of 2,666MHz DDR4 ECC
- AMD Radeon Pro Vega 56 GPU with 8GB of HBM 2.0 memory
- 27-inch display with 5,120 x 2,880-pixel resolution and support for one billion colours (P3 color gamut)
- 1TB SSD

KEY FINDINGS

- We're betting the opening procedure will be the same as it was on the iMac 5K — which is to say, if you can use a pizza cutter, you can open an iMac Pro. With all that glass out of the way, we have a perfect view of the iMac Pro's pristine interior. It would make a lovely wallpaper for someone.
- The first component out is the enormous dual-fan cooler. Looks like Apple sacrificed the 5K's full-size desktop hard drive (not that you'd want that in a pro machine) to make some room here. Also sacrificed to the cooling gods: the external RAM access hatch. Sad face. In exchange, we get a big rear vent and an 80% increase in cooling capacity.
- The power supply connects to the logic board by way of not one, not two, but *four* shiny terminals secured with Torx screws. This design is much closer to what we saw on the 2013 Mac Pro than the plasticky connectors we're used to ripping out of the iMac 5K. It also makes accessing logic board components (apart from the RAM, of course) much, much easier. With the power supply tucked back into the rear shell, we can remove the board right away.
- Time to take a closer look at that display. Turns out it's the same display panel we found in the iMac 5K: LG Display model LM270QQ1. That said, the cabling arrangement and webcam hardware have been moved around — so you can't swap displays between models.
- **Repairability Score:** 3 out of 10 (10 is easiest to repair). The RAM and CPU are both modular, meaning repairs and upgrades are a go — despite what Apple tells you. The dual SSDs are modular, but custom-made by Apple, complicating replacement. Cutting the tape to open the iMac isn't too hard (with the right tools), but it must be replaced to complete any repair. Key replaceable components are buried behind the logic board, requiring a lot of disassembly for access. The loss of the external RAM access hatch makes for much more challenging upgrades compared with the 27-inch iMac 5K. The GPU is BGA-soldered in place — potentially a major drawback on a 'pro' workstation. No easy graphics upgrades are possible, so choose your configuration wisely. ■

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit: **www.ifixit.com**

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epinions

"I found when I first tried to flash a custom recovery (Step 4 in your guide), that it wouldn't stick — a reboot simply meant that the stock Android restored the stock recovery. The workaround ended up being surprisingly simple."

LINEAGEOS INSTALLATION TIPS

Having just installed LineageOS on my Galaxy Nexus three months ago, I thought I'd point out a glitch with some handsets which could stop people dead in their tracks if they don't figure out the workaround. Your guide in *APC* #451 (see page 61) did half-mention the solution in a short comment, but I think it might be worth a more complete explanation. I found when I first tried to flash a custom recovery (Step 4 in your guide), that it wouldn't stick — a reboot simply meant that the stock Android restored the stock recovery. The workaround ended up being surprisingly simple. All that was needed was to use fastboot to reboot to a recovery on my computer. I could then flash LineageOS (and Google Apps), which meant stock Android's protection mechanism for the stock recovery no longer existed. I could only then actually flash the custom recovery and have it stay there.

I've never seen this procedure mentioned anywhere, even though I had no trouble finding an explanation of why I had to do it. Hope this helps any other *APC* readers who encounter this problem.

Geoff Dyer

THE MANY BRAINS OF SIRI

I have an iMac, an iPhone, an Apple Watch and a brand-spanking-new HomePod. Call me a fanboy, yeah, yeah... Something puzzles me about Apple's assistant, Siri, though. She works really well on my phone, watch and the poddy — picking up pretty much everything I say, even if she can't answer each of my queries — but when it comes to the iMac, she seems like a totally different piece of software. She sometimes stops listening when I'm halfway through a really simple request ("Hey, Siri, what's two-and-a-half times seven?") and often begins answering when I'm still talking, or she sometimes just doesn't register I've asked the entire question at all and tells me that "two and a half equals 2.5". Thanks, mate. I've given up trying to talk to her on my iMac because of this. It really puzzles me that Apple has spent so much time and energy (well-spent, in my opinion) in crafting their assistant in the more portable devices, leaving their higher-end products somewhat behind. I suppose they're using the Watch and iPhone as icebreakers, in a way, but if they've made such significant progress with the technology — which I believe they have — then I don't really understand how it's not then a fairly simple process of bringing all devices up to the same level, to have One Siri to Rule Them All, so to speak, rather than a whole range of different versions of varying capabilities.

Stuart Reid

APCMAG@FUTURENET.COM

Come on, have your say!

We want to hear what you think. Add to these discussions or email your views (in fewer than 250 words) to **apcmag@futurenet.com**. All correspondence becomes the property of *APC* and is subject to editing. Letters must include full name, street address, suburb, state and phone number to be considered for print publication. Address and phone details will not be published.

end user

» SHAUN PRESCOTT DIGS INTO THE BIG TECH ISSUES AFFECTING CONSUMERS

It's now illegal for Aussie companies to hide data breaches

New legislation means details must be made public... although certain businesses and institutions have special rights.

Until February of this year, Australian businesses could still choose to keep quiet if they'd been the victim of a serious data breach that had compromised customer data. Traditionally, when a company lost your data – whether that was via robbery, technical fault or bumbling incompetence – you likely wouldn't even know about it unless you were specifically informed. However, thanks to the introduction of a Privacy Act amendment called Notifiable Data Breaches (NDB), it's illegal for Australian companies not to tell you.

And it's not just obviously important bits of data, like credit card numbers, that requires disclosure: the new law covers any data that could render a person "reasonably identifiable", a deliberately flexible term which can account for a whole range of data types. "The NDB scheme introduced an obligation to notify individuals whose personal information is involved in a data breach that is likely to result in serious harm," reads the Office of the Australian Information Commissioner (OAIC) website. "This notification must include recommendations about the steps individuals should take in response to the breach. The Australian Information Commissioner must also be notified of eligible data breaches."

Still, "result in serious harm" is another flexible concept, according to privacy commissioner Tim Pilgrim, speaking to the ABC. A name's presence on some lists (for instance, a list of rude people), might be considered more incriminating than others (on a list of polite people). And with the increasing complexity of social media and machine learning, what may appear to be harmless information could still prove lucrative to identity thieves.

All Federal Government agencies are beholden to the law, and all not-for-profits and businesses with an annual turnover greater than $3 million are likewise affected. For companies that make less than that, but trade in personal information or health services, they must disclose breaches.

Companies are obligated to advise the OAIC, but not always immediately. However, failure to report a breach can result in significant fines: depending on the severity of non-compliance, the institution can issue fines of up to $2.1 million to businesses, or up to $420,000 to individuals. There's also the reputational damage that organisations could suffer if the public learns that it deliberately hid details of a breach.

But are there exceptions? The OAIC specifies that 'enforcement bodies' (such as the AFP, Customs and the Immigration Department) are among the entities under no obligation to report, so long as its "CEO believes on reasonable grounds that notifying individuals would be likely to prejudice an enforcement related activity conducted by, or on behalf, of the enforcement body." If you're worried about how much personal information both the government and law enforcement keep in their coffers, this might present some concern.

One slightly more reassuring aspect of the new law is that it doesn't just apply to Australian businesses and institutions: any overseas entity operating in Australia, such as US-based Uber – famous for its data breaches (and not to mention its exploitation of workers) – must still abide by the new laws. ■

END USER

Share your stories!

If you have an interesting story about technology users, their experiences and the issues that affect us all (whether funny or serious), email us at **apcmag@futurenet.com**. All correspondence becomes the property of *APC* and is subject to editing. Letters must include writer's full name, street address, suburb, state and phone number to be considered for print publication. Address and phone details will not be published.

Head to head: Modern networking technologies

Alex Cox puts on his deerstalker hat to investigate the pros and cons of the big networking options. Which is best? Mesh, Wi-Fi or Ethernet?

A functioning network isn't just a luxury – it's one of life's essentials. Heat, water and delicious broadband piped through the home. But there's a lot to choose from, both in terms of standards and individually within those brackets. We're not here to pick out specific hardware, but if you're looking to renovate your network, you'll need to make the right choice. Will it be good old Wi-Fi? Perhaps its close cousin, mesh? Or do the reliable wires of Ethernet make the most sense? Read on, and choose what works for you.

Round 1

RELIABILITY

Wi-Fi has come a long way since the days of 802.11b. It used to be the purist's favourite sneering target, both for its sorely lacking speed and the fact that anyone operating a microwave within three miles would essentially render the 2.4GHz band unusable. Microwaves still throw out interference, but 5GHz means that's not quite true anymore. That said, lower-end Wi-Fi does have its issues, particularly when there's a lot of competing signals around. Finding a free channel in a built-up area can be tough, and fighting with metal and concrete structures is still a problem. Electromagnetic fields, too, are a big issue for Wi-Fi signals: If you've ever noticed a dip in signal quality over the holidays, you can probably blame those flashing festive lights.

Mesh, given its multiple points of contact, does help to alleviate many of the problems of Wi-Fi reliability. If one node is getting hammered, the second (if it's in range) should be able to back it up – but if you're relying on a wireless backhaul, your problem could simply be made worse. Ethernet? Once it's wired in, it's working – as long as nobody plugs in anything stupid. If stability is your concern, stick to the wires.

WINNER:
Ethernet

Round 2

SPEED

Measuring speed in a Wi-Fi context is difficult, as throughput and lag are often dependent on which specific devices are at either end of the argument. Get a MU-MIMO router and a wireless card that supports multiple channels, keep them free of obstructions, and there's no reason you can't achieve throughput way beyond the maximum capacity of your broadband connection. Mesh might not be quite as easy, because there needs to be a backhaul channel managing communication between the nodes. If, like Linksys' Velop, there's no dedicated wireless radio for this purpose, you may find inter-device communication slightly slower in busy periods. Unless, that is, you choose to do your hauling via Ethernet, at which point, the argument turns on a dime.

Ethernet, even if your home is strung up with drilled-through last-century Cat 5, should be able to support Gigabit networking. It's faster than even wireless. Maximum throughput depends on the quality of cabling as well as rating, and if you're installing today, you'd be a fool not to string up some 10G-compatible Cat 6, which improves Ethernet's susceptibility to crosstalk, as well as boosting its top speed.

WINNER:
Ethernet

Round 3

CONVENIENCE

When you need to get connected, your network had better be there for you. Wherever you are, whatever you're using, you want to be able to get up and online as quickly as possible. While Ethernet has had a good run, this hugely subjective case – because if you're not also running at least a little Wi-Fi alongside your wires, we're a bit confused as to why – is where it falls down. A wireless network, configured properly, is there. It's waiting. Want to hook up a new device? Just sign in. Want to get your friends on board? Let them into your guest network. Portable devices, no problem. And those moments when you're not in range of a convenient Ethernet outlet or cable aren't an issue at all.

Mesh, invariably, makes this even better – extending your Wi-Fi network used to be a massive hassle, with multiple SSIDs and, generally, confused devices. However, with a mesh setup, everything's on the same page by default. Ethernet does have some plus points in this area (there are no passwords to deal with, for example), but mesh, which often offsets its management facilities to an ultra-convenient cell phone app, has it utterly licked.

WINNER:
Mesh

"If we were to presume you come from some alternate reality where you didn't have a network at home, we'd have two choices. The awkwardness of Ethernet is trumped by mesh's flexibility; mesh's expense is beaten by Ethernet's upgradeability."

Round 4

EXPANDABILITY

Device limits in networking are, mostly, pretty theoretical. Your router might say different, but a single Wi-Fi network, in theory, will top out at around 250 connected devices, a limit that even the busiest home is unlikely to reach. In practice, the more devices a Wi-Fi network concurrently manages, the slower the experience will be for everyone. Even modern routers, well-managed in firmware, and toting MU-MIMO radios, can end up sluggish if they're firing off traffic in many multiple directions. Mesh spreads that noise from one radio to multiple nodes throughout your home, and its other benefit is rather obvious: If you want signal where there is no signal, you can just add another node. There's usually a node limit, but not one that would go beyond even the largest mansion.

Ethernet can go a long way — if you need more ports, add another switch — but every new port needs another wire. If you're installing Ethernet in your drywall, it's a darn sight more difficult to bring connectivity to a new room than the same process with a wireless solution, and there's a length limit to cables, so you'll need a repeater if you want to go further.

WINNER:
Mesh

Round 5

PRICE

It's not a technical issue, but price is important when putting the networking techs head to head, particularly because it's mesh networking's big downside. For all the "just grab another node" arguments, that's rarely a cheap solution. In fact, it's often as hard on the wallet as picking up a whole new wireless router, because, in a sense, that's what you're doing. If you're in a smaller home, a single standard Wi-Fi router is probably enough, so you can steer clear of more expensive mesh packages anyway, and if you're lucky, your broadband connection comes with a router. It might be shoddy, but you're paying for it anyway. That's a sunk cost.

Ethernet can be cheap, particularly if you're prepared to wire it yourself, but installing it with professional help is far from inexpensive. That said, a good backbone will last you; line up Cat 6 cable, and you're prepared for future speed upgrades either end of the wires, something that isn't true for either of the wireless solutions. With 802.11ax on the horizon — expect early hardware this year, and realistically adoptable gear in mid-2019 — a big investment in mesh right now might soon sting if you're trying to stay cutting edge.

WINNER:
Wi-Fi

And the winner is...

You know us. Speed and reliability are the core of our being. But new tech is equally important, so this isn't a clear win for Ethernet. Wi-Fi's drawbacks don't completely disqualify it either — we've got along with it just fine so far, and it's due to get better. Wi-Fi and mesh suffer in terms of latency, but they're good enough for most; it's the latter's leap forward in connectivity and expandability that puts it leagues ahead of its one-node cousin.

So if we were to presume you come from some alternate reality where you didn't have a network at home, we'd have two choices. The awkwardness of Ethernet is trumped by mesh's flexibility; mesh's expense is beaten by Ethernet's upgradeability. We'll skip over the irony of mesh working best if supported by an Ethernet backhaul, because we have to peg it as our networking pick. It's the easiest way to fill your home with rock-solid wireless networking, it has easy configuration options, and it's only going to improve. Don't throw out your Wi-Fi router if you're not struggling for signal, but consider mesh your next upgrade. ■

AMD CPU

$235 | WWW.AMD.COM

AMD Ryzen 5 2400G

Discrete-level graphics finally come to desktop processors.

Before Ryzen, AMD was best known for its incredibly affordable Athlon APUs. Many of these system-on-a-chip units, combining processor cores with onboard graphics, went into affordable gaming PCs and home theatre PCs. So when we went a complete year without any Ryzen-based APUs, we were a bit disappointed.

Thankfully, AMD is finally delivering the goods with APUs not only based on Ryzen, but also featuring AMD Vega graphics built right into chip, led by the APC award-winning AMD Ryzen 5 2400G. These aren't your run-of-the-mill integrated graphics either. Rather, the company is calling the onboard Vega GPU 'discrete-class graphics'.

We've taken AMD's claims to the task and came away amazed by the chip's ability to game at 4K and high-quality settings without having to plug in a graphics card. Combined with slightly improved processor performance and an amazing price, the AMD Ryzen 5 2400G is one of our favourite chips that'll work for many affordable PC builds.

The AMD Ryzen 5 2400G arrives to replace the Ryzen 5 1400, one of the most value packed 4-core/8-thread processors, which released last April at about the same price. In this way, the 2400G is the definition of getting more for your money.

Not only is it a faster processor built upon a matured Zen architecture, there's also the onboard Vega 11 graphics. Though its 11 compute units that clock up to 1,250MHz might not sound very impressive compared to Kaby Lake G's minimum of 20 compute units flying at 1,011MHz, the Ryzen 5 2400G got us plenty excited with playing *Overwatch* at 4K – more on that soon.

This processor also has a ton more integrated graphics muscle than Intel's competing Core i5-8400 ($259) and Core i3-8350K ($239).

You can buy and AMD Ryzen 5 2400G at all the regular trustworthy online retailers here in Australia, such as Mwave and PLE Computers.

Not to be confused with Ryzen 2nd generation, the processor side of AMD's Ryzen APUs are still part of the Zen architecture that made the original Ryzen processors a legend. But that's not to say this is just a freshly printed Ryzen 1400 processor with an integrated GPU.

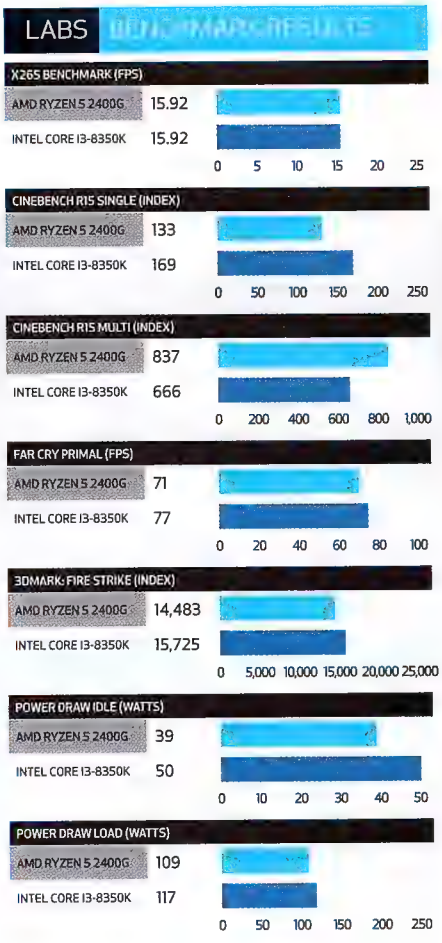
Thanks to AMD's new 14nm+ process and Raven Ridge architecture, the Ryzen 5 2400G runs at a 0.2GHz faster base clock, and the chip's boost clock has also been increased by a factor of 0.5GHz compared to its predecessor.

Beyond that, AMD promises its new Raven Ridge design also reduces cache and memory latencies, helping the processor to perform faster with all workloads – especially gaming.

One down note of the Raven Ridge design is that the type of supported PCIe lanes has dropped from x16 to x8. This hasn't really limited the speed of NVMe SSDs or high-end graphics cards in our stable, but it could stunt the growth of your PCs if components become exponentially more powerful and faster in the near future.

Looking at how the AMD Ryzen 5 2400G performs compared to its predecessor in our benchmarks, Cinebench shows greater multi-threaded performance, while GeekBench reveals better

AMD
RYZEN
5
THIS BOX INCLUDES AN AMD RYZEN™ PROCESSOR WITH RADEON™ VEGA GRAPHICS, AMD THERMAL SOLUTION, INSTALLATION INSTRUCTIONS, AND LIMITED WARRANTY INFORMATION.


LABS
X265 BENCHMARK (FPS)
AMD RYZEN 5 2400G 15.92
INTEL CORE I3-8350K 15.92
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CINEBENCH R15 SINGLE (INDEX)
AMD RYZEN 5 2400G 133
INTEL CORE I3-8350K 169
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AMD RYZEN 5 2400G 39
INTEL CORE I3-8350K 50
0 10 20 30 40 50
POWER DRAW LOAD (WATTS)
AMD RYZEN 5 2400G 109
INTEL CORE I3-8350K 117
0 50 100 150 200 250

"You can truly skip getting a graphics card with this chip – especially in these terrible times with cryptocurrency mining inflating the prices on all graphics cards."

single-core performance. Improvements on these two fronts ultimately lead this chip to transcode video in Handbrake at a steadier rate than the Ryzen 5 1400.

Unfortunately, even with AMD's year-on-year processor performance improvements, it still can't match up to Intel's processing prowess. The Intel Core i3-8350K runs away with significantly faster single- and multi-core scores in both GeekBench and Cinebench (using an aggregate or results found on the web). Meanwhile, the slightly more expensive, but hexa-core, Intel i5-8400 simply blows away both the quad-core processors.

The good news is AMD's Vega integrated graphics are leagues ahead of Intel UHD graphics. Whereas we were lucky to run *Rocket League* at over 10 frames-per-second (fps) at 640 x 480 resolution with every graphical setting turned all the way down on an Intel Core i5-8400, we had an absolutely playable 30fps experience on the AMD Ryzen 5 2400G with the game set to a 1080p resolution and high-quality settings.

What's even more impressive is we were able to kick the graphical quality settings in *Overwatch* to 'Epic' and the resolution to 3,840 x 2,160, and still get a completely playable 30fps experience. Only *Destiny 2* proved to be too much for the AMD Ryzen 5 2400G's integrated graphics, in which it had a rougher time staying at 30fps with occasional drops to 15fps while playing the game at 1080p and high-quality settings.

Unfortunately, during our testing, we ran into an issue of getting the AMD Ryzen 5 2400G to play nice with the Nvidia GTX 1080 Ti we use for testing. Due to pre-release drivers, there were complications between the 'discrete-class' Vega graphics and any actual discrete graphics card we tried to plug in. We're working with AMD to resolve the issue.

The AMD Ryzen 5 2400G's temperatures also don't see as an amazing improvement. Rather, the processor hits a higher peak of 56° Celsius, thanks to integrated graphics churning away right next to the processor cores.

Last year, we thought the Ryzen 5 1400 was an amazing value for a quad-core, eight-thread processor, and now the AMD Ryzen 5 2400G is an even better deal. The processor might only perform slightly faster than the last generation, computationally speaking, but the strength of AMD's onboard Vega graphics is astonishing.

Whether you're looking to build a compact home theatre or just starting on an eSports gaming PC, this is the perfect APU to buy.

What's more, you can truly skip getting a graphics card with this chip – especially in these terrible times with cryptocurrency mining inflating the prices on all graphics cards.

With that, the AMD Ryzen 5 2400G earns all five of its glorious stars here.

Kevin Lee

Verdict

Features	★★★★★
Performance	★★★★★
Value	★★★★★

The first APU to get us giddy about integrated graphics. Plays today's games at 1080p & high-quality settings.

★★★★★

AMD CPU

$139 | WWW.AMD.COM

AMD Ryzen 3 2200G

The ultimate choice for PC gaming on a budget.

If you're looking to build a PC as affordably and small as possible, an APU – an AMD processor equipped with onboard integrated graphics – is the best way to do it.

At the very bottom of AMD's APU stack, the company has introduced the AMD Ryzen 3 2200G, a quad-core processor with serious 'discrete graphics' that altogether costs less than the cheapest graphics card. In our book, it's the ultimate choice for PC gaming on a budget.

Just $139 is none too shabby for a quad-core, four thread processor, further backed up by eight graphics compute units and a 1100MHz max GPU clock. The 2200G is a noticeably more affordable proposition than the $169 Intel Core i3-8100, which packs as much computing power but far weaker integrated graphics.

Compared to the $149 AMD Ryzen 3 1200 it replaces, the Ryzen 3 2200G is a tad more affordable on top of being a complete upgrade with higher clock speeds and the addition of integrated graphics.

The AMD Ryzen 3 2200G might be part of the start of the new Ryzen 2000-series, but it isn't technically part of forthcoming wave of Ryzen 2nd-gen processors. Rather than being built upon Zen+ new 12nm architecture, the Ryzen APUs utilize Global Foundries' new 14nm+ FinFET process that's more of a mature version of Ryzen's original Zen architecture.

That said, AMD's new Ryzen APUs do get a few new features. Precision Boost 2 allows the 2200G to boost more cores and more often on different workloads. Meanwhile, updated SenseMi tech allows this chip to streamline processor power consumption. When X470 motherboards begin to roll out later this year, we'll likely see even better power savings and performance.

Of course, the real magic behind AMD's new Raven Ridge processors is the integration of AMD Vega graphics, and they give this chip a real wallop of graphical power for everyday PC gaming.

Despite having fewer compute units and slower GPU clock speeds than the AMD Ryzen 5 2400G, the Ryzen 3 2200G felt every bit as capable as its bigger brother. We were able to play *Rocket League* at 1080p and high-quality settings at a steady 30fps. We had a similar experience in *Destiny 2*, but experienced as many frame rate stutters as we did on the Ryzen 5 2400G. Meanwhile, it had no problems with *Overwatch* at 30fps, 4K and 'Epic' quality settings.

Unfortunately, due to having fewer threads than the AMD Ryzen 5 2400G, you'll see a significant dip in multi-core performance between the two APUs. That said, this chip is a welcome improvement on its predecessor, scoring a few hundred points higher in both Cinebench and GeekBench's respective single- and multi-core tests.

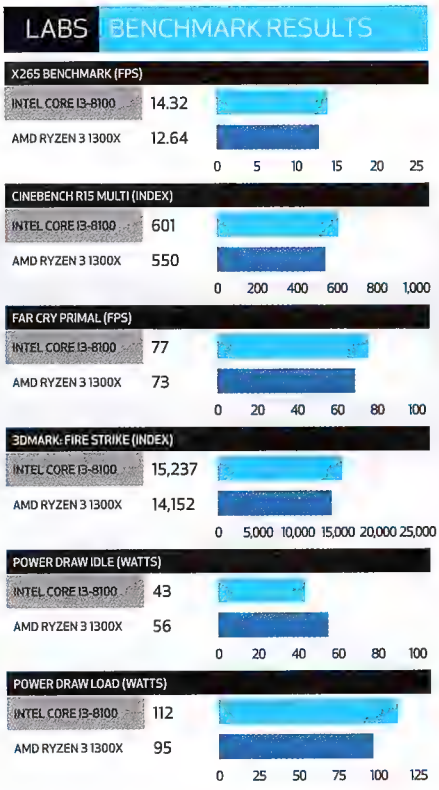
Compared to the Intel Core i3-8100 (opposite), Team Blue still leads in overall computational performance. While the difference isn't too great in Cinebench, Intel's most affordable processor steam rolls AMD's part with 4,624 single-core and 13,400 multi-core GeekBench scores. All up, we would say this is the best APU to date from a value perspective, and easily a first choice pick for anyone looking to build their first gaming PC on a budget. ■ **Kevin Lee**

Verdict

Features	★★★★★
Performance	★★★★½
Value	★★★★★

The 2200G is the ultimate budget part that gives you all the processing and graphical power you need.

★★★★½


LABS BENCHMARK RESULTS
X265 BENCHMARK (FPS)
INTEL CORE I3-8100 14.32
AMD RYZEN 3 1300X 12.64
0 5 10 15 20 25
CINEBENCH R15 MULTI (INDEX)
INTEL CORE I3-8100 601
AMD RYZEN 3 1300X 550
0 200 400 600 800 1,000
FAR CRY PRIMAL (FPS)
INTEL CORE I3-8100 77
AMD RYZEN 3 1300X 73
0 20 40 60 80 100
3DMARK: FIRE STRIKE (INDEX)
INTEL CORE I3-8100 15,237
AMD RYZEN 3 1300X 14,152
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POWER DRAW IDLE (WATTS)
INTEL CORE I3-8100 43
AMD RYZEN 3 1300X 56
0 20 40 60 80 100
POWER DRAW LOAD (WATTS)
INTEL CORE I3-8100 112
AMD RYZEN 3 1300X 95
0 25 50 75 100 125

$169 | WWW.INTEL.COM.AU

Intel Core i3-8100

Proof that processors are still advancing at an impressive rate.

There were lots of reasons to get excited about Intel's eighth-generation (Coffee Lake) Core processors, but for this reviewer, it was the promise of this particular chip that produced the excitement. The reason is straightforward enough – it potentially offers the best bang for your buck of any of the new chips. The good news (if slightly premature in terms of this review), is that it delivers on that potential and, in fact, for many system builders, now becomes the go-to chip for most budgets, and even mainstream plans.

We'll get to the reason for this glowing preamble shortly, but before we do, it's worth going over what your $169 gets you. The Core i3-8100 lacks Hyper-Threading and a Turbo boost, but it does pack four cores into its LGA 1151 package, thrumming along at a perfectly serviceable 3.6GHz. Unlike the Core i3-8350K we looked at a couple of issues ago, this is a simple chip that isn't designed with overclocking in mind, which has an upside in that it operates with a TDP of 65W, so the standard Intel cooler that it ships with handles your needs well enough.

If you're looking to build a budget system around this chip, you're still limited to a single chipset at this point, which starts at around $180 for a reasonable Z370 motherboard. It's the current cost of memory that is the most frustrating, though, which means that the core components of CPU, motherboard, and RAM start at around $450. You do get Intel's UHD 630 integrated graphics in the Core i3-8100, though, which may not be relevant for modern gaming, but it's a solid enough solution for normal desktop use, and – thanks to QuickSync – can handle video encoding while it's at it.

So why all the love for this budget chip? Because this chip is essentially what sold as a mainstream offering two generations ago – in fact, its performance is as close to the stock performance of the Core i5-6600K as you can get. That's a chip that will still set you back $350 or more. Of course, that chip that can be overclocked and turbos up to 3.9GHz, but for the most part, there really isn't much to separate the two, apart from halving the price tag on the new processor.

When it comes to the benchmarks, you'll find two comparisons for this chip – the aforementioned Core i5-6600K and the closest new chip from AMD, the $169 Ryzen 3 1300X. It's worth noting that the AMD offering doesn't have integrated graphics, which may be a factor if you're not interested in games (this is where AMD's recently released APUs come in, see opposite). The results from benchmarking are clear, with Intel's budget offering giving AMD's chip a sound thrashing, with the exception of power draw under load.

If we have reservations, it's that $169 is still a hefty chunk of cash for those on an extremely tight budget. There is a lot of power on offer here, though, and all those cores should keep this chip relevant for years to come. We do wish that the budget motherboard chipsets would launch, so we can see how low we can get that core component price tag, but that doesn't detract from the fact that this is a great buy right now.

It's arguably the most important Coffee Lake chip so far.

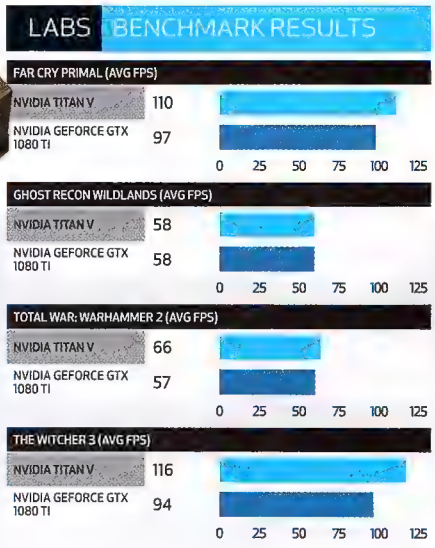
Alan Dexter

Verdict

Features	★★★★½
Performance	★★★★½
Value	★★★★★

Impressive value, strong performance and functional integrated graphics at a fairly reasonable budget price.

★★★★½


LABS BENCHMARK RESULTS
FAR CRY PRIMAL (AVG FPS)
NVIDIA TITAN V 110
NVIDIA GEFORCE GTX 1080 TI 97
0 25 50 75 100 125
GHOST RECON WILDLANDS (AVG FPS)
NVIDIA TITAN V 58
NVIDIA GEFORCE GTX 1080 TI 58
0 25 50 75 100 125
TOTAL WAR: WARHAMMER 2 (AVG FPS)
NVIDIA TITAN V 66
NVIDIA GEFORCE GTX 1080 TI 57
0 25 50 75 100 125
THE WITCHER 3 (AVG FPS)
NVIDIA TITAN V 116
NVIDIA GEFORCE GTX 1080 TI 94
0 25 50 75 100 125

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Nvidia Titan V

How to build your own Skynet.

Nvidia's Titan series of graphics cards has always been more about status than practicality, and waiting a few months could usually net you nearly the same level of performance for about half the price. This time, rumours are swirling about Volta, suggesting we might not even see GeForce variations, and instead will get Ampere GPUs later this year. That's not really a problem, assuming Ampere is to the GV100 what the GP104 was to the GP100. The problem is that GV100, for all its performance, has a lot of extra design elements that simply aren't ideal for graphics workloads.

Take the 64 CUDA cores per SM (streaming multiprocessor), with 32 FP64 (floating point) cores, and the ability to do twice as many packed math (FP16) operations as FP32 ops. FP64 isn't something games use or even need, though there may be some algorithms where the packed math support proves beneficial. Even more than this, the presence of the new Tensor cores — eight per SM — takes a lot of space, and these cores are special-purpose constructs designed to accelerate FP16 machine learning operations. Toss in HBM2, and you have a very large, very expensive core that's not a great fit for consumer workloads. That's why Nvidia is marketing the Titan V not at extreme gaming, but at machine learning researchers. Without such a product, the only way to get access to Nvidia's Tensor cores would be through DGX-1 servers, or a few cloud computing options. But the DGX-1 is back-ordered, and even if it wasn't, it runs at US$149,000 per server, including eight Tesla V100 cards. Five grand for a Titan V that includes all the core features is a bargain by comparison, and opens the door for university researchers to come to grips with the technology before moving to larger supercomputing installations.

The Titan V is a potent solution for both machine learning and graphics work, easily claiming top honors in our gaming test suite. But how does it perform if we throw caution to the wind and overclock it? We managed to push the core clocks up by 150MHz and the HBM2 by 125MHz. Combined with maxing out the power limit — and the fan speed — performance improves by a substantial 25–30%, but the GPU starts hitting thermal and power limits, meaning there's potentially even more headroom available.

Even redlining a GTX 1080 Ti or Titan Xp, you're not coming anywhere near the overclocked Titan V. However, it is worth noting that the Titan V doesn't include SLI connectors, so while running multiple cards for machine learning purposes is possible, you're not going to be able to improve gaming performance beyond what you get with a single card.

Regardless of whether Volta GPUs show up in GeForce cards in the coming months, some variation on the gaming aspects of the Titan will almost certainly appear. Give us 12GB GDDR6 and the same 5,120 FP32 CUDA cores (or more) but in a smaller, more affordable package, and it will be awesome. Our next super high-end rig is already on the drawing board...

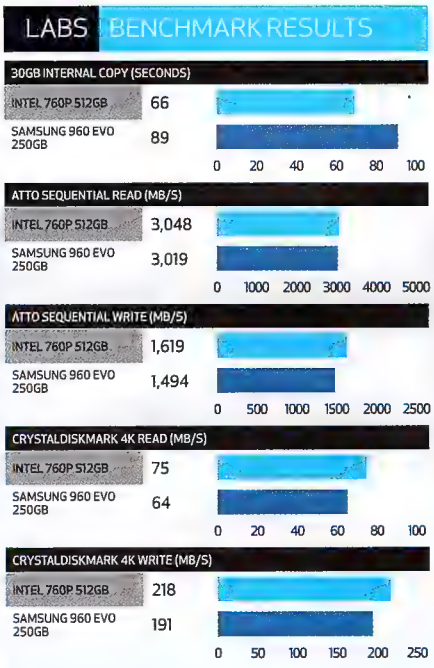
As for the Titan V, unless you're after a machine learning tool, save your money and wait for the next generation non-Titan cards to arrive. ■ **Jarred Walton**

Verdict

Features	★★★★★
Performance	★★★★★
Value	★

It's the fastest GPU around, but don't grab this for gaming. The beast is marketed for machine learning.

★★★½☆


LABS BENCHMARK RESULTS
30GB INTERNAL COPY (SECONDS)
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CRYSTALDISKMARK 4K WRITE (MB/S)
INTEL 760P 512GB 218
SAMSUNG 960 EVO 250GB 191
0 50 100 150 200 250

FROM $119 (128GB) | WWW.INTEL.COM.AU

Intel 760P SSD 512GB

NVMe performance for mainstream money.

Good performance, solid reliability, and no obvious holes in the feature set. That's what we want. Handily, that's exactly what Intel's latest SSD offers. In theory, at least.

As a PCI Express drive in the M.2 form factor, with NVMe control protocol support, it checks all the boxes we like to see from a contemporary SSD. It's also competitively priced for a drive with such a complete feature set. Thus, the Intel 760P SSD represents one of a new generation of what you might call mainstream NVMe drives.

Enabling it all is Intel's latest 64-layer 3D TLC NAND flash memory and a new Silicon Motion controller chipset. Like the 600P before it, the 760P has a customised version of Silicon Motion's firmware. But this time, Intel has used Silicon Motion's latest hardware in the SM2262 controller, albeit the mid-range flavour of Silicon Motion's latest NVMe controller family. As for that flash memory, it's actually the same stuff you'll also find in Intel's 545 SATA drives. The 760P blows the 545 away for claimed performance, which tells you all you need to know about the limitations of the SATA interface and the antediluvian AHCI control protocol associated with it. PCI Express and NVMe really are a killer combo.

At launch, Intel is offering the 760P in 128GB, 256GB, 512GB, 1TB and 2TB. In terms of comparative performance across the range, the 128GB model is conspicuous for offering significantly lower drive performance. But in 512GB format (as tested here), you're looking at something approaching the 760P's optimal configuration for performance.

Intel claims 3230MB/s for sequential reads and 1625MB/s for writes; 4K random reads are rated at 340,000 IOPS, and writes at 275,000 IOPS. In other words, this is a quick drive, though it's not trying to be the very quickest. But the 760P is also not a budget NVMe drive. There are a few even cheaper NVMe options that achieve their cheap pricing by corner-cutting, such as dropping the PCIe lane count down from four to two, or ditching the DRAM cache memory – but not here. This is a full feature drive.

In terms of peak performance, it's no slouch, with reads of around 3GB/s and writes of 1.6GB/s. But by way of example, Samsung's 960 Pro cranks out 3.4GB/s reads. Similarly, if it's random access performance you crave, the 760P doesn't get anywhere near Intel's own 900P. Of course, the 900P is a far more expensive drive, and leverages Intel's exotic 3D XPoint technology.

More relevant, you could argue, is the comparison with the likes of Samsung's 960 Evo, a more affordable alternative to the 960 Pro, and one which also uses 3D TLC NAND memory. Our review sample for the 960 Evo was the 250GB model, and thus not a direct competitor for this 512GB 760P model, but the overall picture is of a pair of well matched drives.

It's also worth noting that the 760P has Samsung's previous flagship, the 950 Pro, well beaten. Factor it all in and you have a drive that very much delivers on its remit. The 760P is all about delivering bang for your buck. There are clearly faster drives, but they are also unambiguously more expensive. As a real-world buy, the 760P looks awfully tough to beat.

Jeremy Laird

Verdict

Features	★★★★½
Performance	★★★★½
Value	★★★★½

Excellent feature set, terrific all-round PCIe-powered performance and great bang for buck.

★★★★½

3.5-INCH HARD DRIVE

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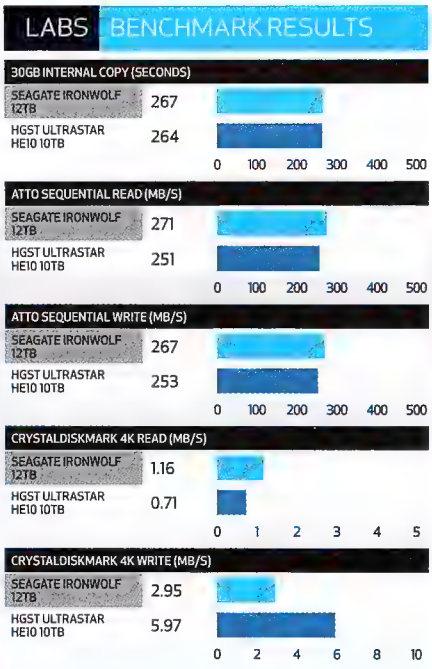
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ATTO SEQUENTIAL READ (MB/S)
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SEAGATE IRONWOLF 12TB 2.95
HGST ULTRASTAR HE10 10TB 5.97
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Seagate IronWolf 12TB

Who's afraid of the big, bad IronWolf?

These days, storage is all about solid state. SSDs provide not only the fastest performance, they also offer the largest capacities – for a price. But if you want maximum storage density for the minimum possible price, then you'll need an old-school magnetic hard drive.

With that in mind, it's no surprise to find that conventional hard drive technology marches on despite its relegation to a relatively small niche. A little over a year ago, the biggest mainstream hard drives weighed in at 10TB. Now we're reviewing our first 12TB drive, the Seagate IronWolf.

It's closely related to the Seagate Barracuda Pro, but further optimised for NAS applications. In other words, if you've got a NAS box that's set for a drive upgrade, the IronWolf would like to offer its services. Indeed, Seagate offers two versions of the IronWolf: vanilla and Pro. This vanilla drive is aimed at connected homes, SOHO, and SMB apps, while the Pro is for full-on commercial and enterprise users. Both are packed with features, such as Seagate's AgileArray tech, which involves RAID optimisation, dual-plane balancing and advanced power management. Then there's Rotational Vibration (RV) mitigation, including several RV sensors that help maintain performance in multi-drive NAS enclosures that can transmit significant vibrations.

In 12TB trim, the IronWolf sports a total of eight platters, thus 1.5TB per platter. As a consequence, its 3.5-inch chassis is crammed. The usual recesses on the bottom of the drive are nowhere to be seen. Rounding the main feature set out is the 7,200rpm spindle speed and a chunky 256MB of cache, all running through a standard SATA 6Gb/s interface. Overall, this 12TB model is rated at 180TB per year of data traffic, has an MTBF (mean time between failures) of 1 million hours, and a 3-year limited warranty.

For context, the IronWolf Pro is optimised for 300TB per year, has an MTBF of 1.2 million hours, and a 5-year warranty. In reality, there's probably little in it in terms of the hardware. What we're looking at is one hell of a lot of storage for a pretty reasonable price.

Granted, a 3TB or 4TB drive may offer marginally more storage per dollar, but the 12TB IronWolf is pretty competitive in that regard, and offers unbeatable data density. You could, for instance, swap out all the 3TB drives from a quad-drive NAS enclosure for just one of these puppies, and then add further drives when needed or wanted.

So the IronWolf looks good on paper and offers a pleasing capacity-to-dollar ratio. But how does it perform? By the standards of a conventional magnetic drive, it's seriously swift. You're looking at sequential reads and writes in the 260–270MB/s region. The 4K random access performance is where magnetic tech really shows its age, compared to solid-state storage. 4K reads of around 1MB/s and writes just under 3MB/s would be utterly catastrophic for an SSD; but for this type of drive, they're very much competitive.

The bottom line is that you're not going to get anywhere like the performance of even a budget SSD. But that was a given. If you want major storage density at a reasonable price, however, the IronWolf achieves that, and throws in excellent performance for this type of drive. ■ **Jeremy Laird**

Verdict

Features	★★★★½
Performance	★★★★½
Value	★★★

For a magnetic hard drive, this has great performance and a neat feature set, even if it's not the best for TB/$.

★★★★☆

ULTRABOOK

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Dell XPS 13 (2018)

The archetypal Windows ultrabook gets its first major refinement in 4 years — but it's not without cost.

Since it was introduced around 4 years ago, Dell's XPS 13 has had many competitors try to topple it, but despite its ageing design, it has managed to remain the slim-and-light Windows laptop to beat. With this latest 2018 refresh (also known as the XPS 13 9370), Dell wisely isn't messin' with what ain't broken — it's tweaked that design slightly to make it slightly sleeker and lighter.

The biggest physical change is that the body width has been reduced by about 20% — when closed, it's shrunk from 15mm at its widest point to 11.6mm. That's resulted in a bunch of other changes which are a bit of a mixed bag. One of the more controversial aspects is that it's ditched both its predecessor's full-sized (aka 'Type-A') USB ports — you only get three Type-Cs this time around, two of which are Thunderbolt 3 compatible. To its credit, Dell has thoughtfully included a C-to-A adapter cable in the box. That slimmer body has also meant a full-sized SD card reader won't fit anymore — it's been replaced by a microSD slot. You do still get a 3.5mm headset socket.

As we mentioned above, the overall weight has been reduced, dropping from 1.29kg to 1.21kg — not a huge amount, but something that's nevertheless welcome in a laptop that's focused on maximum portability.

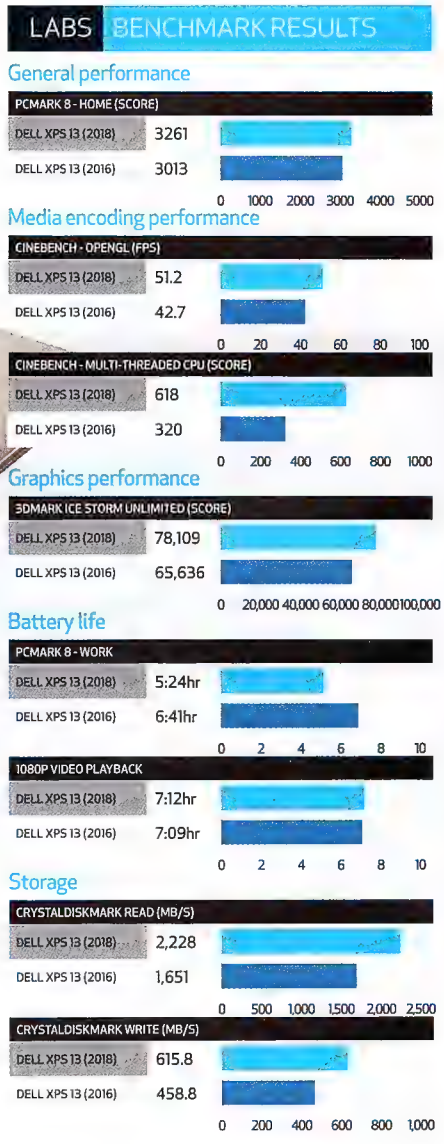
Otherwise, the exterior of the XPS 13 is very similar — the machined-aluminium lid and base makes it tough and fairly resistant to bumps and scrapes, and the carbon fibre palm rest is likewise very tough and wears well. The backlit chiclet keyboard and medium-sized trackpad remain basically unchanged — we actually prefer the XPS 13's keys to the shorter-throw models in the latest MacBook Pros (something you can't often say in Dell vs Apple contests).

The display is A-grade as before, with just 5mm bezels on the top and sides — we tested the 4K touchscreen model, but there's also a matte-finish 1080p version, which'll save you a few bucks and should help extend battery life a tad.

Upgraded 8th-gen Core i internals have given this new unit a performance boost of 15–30% across the board compared to its late 2016 edition, although there is one area that's suffered slightly: battery life. The latter's always been on of the XPS 13's most impressive features, and while this 2018 model manages to remain broadly competitive — ranging from 4 to 7 hours, depending on the task — when it comes to moderate everyday workloads, it's dropped from around 6.5 to 5.5 hours compared to its predecessor. Some of that comes from its slightly smaller battery — part of the price you pay for that slimmer chassis.

Whether this new design's trade-offs are worth it will depend on what your specific needs are. Thankfully, Dell is still selling the previous '9360' model (which was updated with 8th-gen Core i parts), so you've got a choice between old and new.

Whichever model you choose, the XPS 13 remains one of the most compelling Windows ultrabooks available — and it's still our first choice. ■ **Dan Gardiner**


LABS BENCHMARK RESULTS
General performance
PCMARK 8 - HOME (SCORE)
DELL XPS 13 (2018) 3261
DELL XPS 13 (2016) 3013
0 1000 2000 3000 4000 5000
Media encoding performance
CINEBENCH - OPENGL (FPS)
DELL XPS 13 (2018) 51.2
DELL XPS 13 (2016) 42.7
0 20 40 60 80 100
CINEBENCH - MULTI-THREADED CPU (SCORE)
DELL XPS 13 (2018) 618
DELL XPS 13 (2016) 320
0 200 400 600 800 1000
Graphics performance
3DMARK ICE STORM UNLIMITED (SCORE)
DELL XPS 13 (2018) 78,109
DELL XPS 13 (2016) 65,636
0 20,000 40,000 60,000 80,000 100,000
Battery life
PCMARK 8 - WORK
DELL XPS 13 (2018) 5:24hr
DELL XPS 13 (2016) 6:41hr
0 2 4 6 8 10
1080P VIDEO PLAYBACK
DELL XPS 13 (2018) 7:12hr
DELL XPS 13 (2016) 7:09hr
0 2 4 6 8 10
Storage
CRYSTALDISKMARK READ (MB/S)
DELL XPS 13 (2018) 2,228
DELL XPS 13 (2016) 1,651
0 500 1,000 1,500 2,000 2,500
CRYSTALDISKMARK WRITE (MB/S)
DELL XPS 13 (2018) 615.8
DELL XPS 13 (2016) 458.8
0 200 400 600 800 1,000

Verdict

Features ★★★★½
Performance ★★★★½
Value ★★★★

The upgrades haven't come without trade-offs, but this is still Windows' most compelling ultrabook.

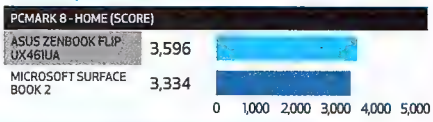
★★★★☆

GAMING LAPTOP

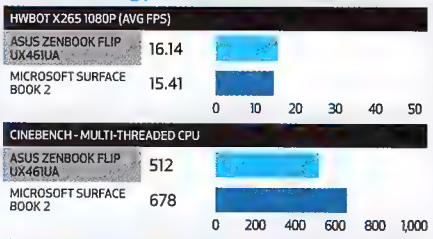
FROM $1,698; AS TESTED, $1,998 | WWW.ASUS.COM/AU

LABS BENCHMARK RESULTS

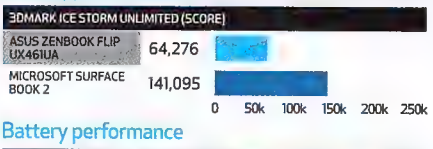
General performance



Media encoding performance


HWBOT X265 1080P (AVG FPS)
ASUS ZENBOOK FLIP UX461UA 16.14
MICROSOFT SURFACE BOOK 2 15.41
0 10 20 30 40 50
CINEBENCH - MULTI-THREADED CPU
ASUS ZENBOOK FLIP UX461UA 512
MICROSOFT SURFACE BOOK 2 678
0 200 400 600 800 1,000

Gaming performance


3DMARK ICE STORM UNLIMITED (SCORE)
ASUS ZENBOOK FLIP UX461UA 64,276
MICROSOFT SURFACE BOOK 2 141,095
0 50k 100k 150k 200k 250k

Battery performance

ASUS ZenBook Flip UX461UA

Does this new 2-in-1 offer the best of both the tablet and laptop worlds?

The only PC category that's still seeing substantial growth seems to be 2-in-1s, with detachables and convertibles continuing to steal a lot of customers from the shrinking tablet market. From a consumer perspective, we guess it makes some sense to put a bit of extra money into a laptop to gain the ability to also use it as a tablet – and in some cases, also net you a faster SSD, a more powerful CPU or even, in some cases, a dedicated GPU for better gaming.

ASUS's 1.4kg ZenBook Flip UX461U, is perhaps not quite as comfortable to use in tablet mode as a detachable or a straight-up slate, but for people who will only use the tablet form occasionally, it does perform adequately as a tablet. There are caveats, with that 14-inch size meaning it's a little too big to easily hold with one hand (even though it's light for a laptop, it's about double the weight of your average high-powered slate) and, as with all 2-in-1s that use this folded form factor, it's a little jarring that your supporting-hand has to cling to keyboard keys. The included 1,024-pressure-point stylus and the fully foldable design do make it good as a desktop slate or drawing display, however, which does somewhat help make up for the less-than-ideal handheld tablet experience.

As a laptop, the Flip looks and feels great, sharing the premium concentric brushed-metal casing of the broader ZenBook line and keeping its compact form factor at an impressively-slim 1.39cm thickness. There's some clever engineering in the hinge design which folds to give the keyboard face a comfortable typing incline without thickening the overall body design, and although it lacks a built-in Ethernet port, just about every other interface you'd want is there, including an HDMI-out, one Type-C and two Type-A USB 3.1 ports, a microSD card slot and a 3.5mm headphone socket.

That foldable facade conceals a mobile series Core i7-8550U CPU (or, in its cheaper iteration, an Intel Core i5-8250U) that is thermally serviced by a single, edge-mounted vent left of the keyboard. This was accompanied by 16GB of RAM and a 256GB SanDisk M.2 SSD (connected via the SATA 6Gbps interface) on the model we tested. This is a powerful configuration for a nearly tablet-sized setup, and the new 8th-generation Intel CPU showed a 10% performance boost on last year's Toshiba Portégé X20W-D (which runs on a Core i7-7600 CPU with the same amount of RAM) in PCMark 8's Home general-productivity benchmark. The Flip manages to last a full 7 hours during video playback tests on balanced power settings, too.

While its CPU is a top bit of kit, a growing selection of premium ultrabooks are beginning to offer dedicated GPUs, so you'll want to be sure that you prefer the tablet features over being able to lightly game, mine cryptocurrency or 3D model anything. There's just an integrated Intel UHD Graphics 620 chip here, which is outperformed by entry-level dedicated GPUs.

Thankfully, the price of the Flip is competitive. It undercuts the similarly specced HP Spectre x360 convertible by about $500.

If you're looking for a laptop that you'll need to use as a tablet on occasion, then the Zenbook Flip UX461UA is the best value 2-in-1 we've come across.

Joel Burgess

Verdict

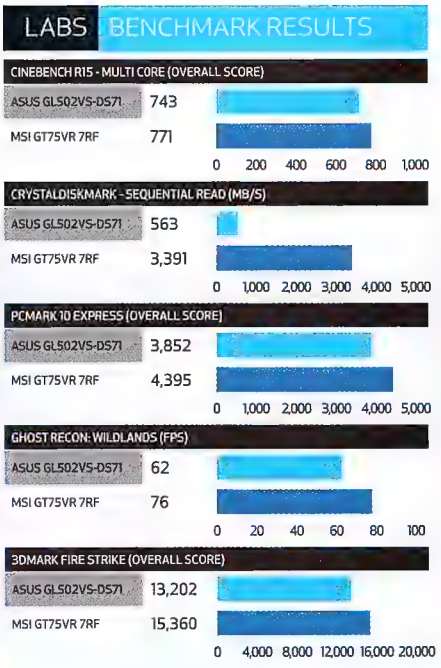
Features	★★★★½
Performance	★★★★½
Value	★★★★½

A powerful and well-priced convertible laptop that performs adequately as an occasional-use tablet.

★★★★½

GAMING LAPTOP

$4,800 | AU.MSI.COM


LABS BENCHMARK RESULTS
CINEBENCH R15 - MULTI CORE (OVERALL SCORE)
ASUS GL502VS-DS71 743
MSI GT75VR 7RF 771
0 200 400 600 800 1,000
CRYSTALDISKMARK - SEQUENTIAL READ (MB/S)
ASUS GL502VS-DS71 563
MSI GT75VR 7RF 3,391
0 1,000 2,000 3,000 4,000 5,000
PCMARK 10 EXPRESS (OVERALL SCORE)
ASUS GL502VS-DS71 3,852
MSI GT75VR 7RF 4,395
0 1,000 2,000 3,000 4,000 5,000
GHOST RECON: WILDLANDS (FPS)
ASUS GL502VS-DS71 62
MSI GT75VR 7RF 76
0 20 40 60 80 100
3DMARK FIRE STRIKE (OVERALL SCORE)
ASUS GL502VS-DS71 13,202
MSI GT75VR 7RF 15,360
0 4,000 8,000 12,000 16,000 20,000

MSI GT75VR 7RF Titan Pro

A big, loud and pricey 'everything including the kitchen sink' gaming laptop.

What happens when you put the equivalent of a complete desktop into a notebook chassis, plus a bit of desk? MSI's GT75VR 7RF Titan Pro answers that question.

It's gigantic. We've tested some large laptops over the years, but at more than 5.5cm thick, the Titan Pro is absolutely massive. A good portion of that is due to the cooling solution, with more than 10 heat pipes, dual exhausts, and twin super-large, 29-blade fans (more on those later). Adding to the heft is the SteelSeries mechanical keyboard, and while its removable keycaps are still chiclet in style, they have a satisfying click that feels great.

The Titan's insides are quite impressive as well. Computing duties are handled by an Intel Core i7-7820HK processor paired with a whopping 64GB of DDR4-2400 RAM. Storage is capacious, too: 1TB, courtesy of two 512GB M.2 PCIe SSDs in RAID 0, paired with additional storage via a 1TB 7,200rpm HDD. The former is definitely impressive, offering sequential read/write speeds of 3,391/2,947MB/s in CrystalDisk QD32. It also scored excellently in PCMark 10 Express, with 4,395, one of the highest scores we've seen in a laptop.

The Titan Pro is available in several SKUs, dependent on how you like to game. For the display, you can choose between a 4K IPS panel or a higher refresh rate 120Hz 1080p screen that's a TN panel — both with G-Sync. We tested the former, and while colours looked great, it left us wanting more. We generally try to avoid 4K screens on gaming laptops, as the GPU power required to maintain 60fps in the latest games is difficult even for top-end desktops. The unit we tested came with a single GeForce GTX 1080, which is more than capable at 1080p but can struggle at 4K. (There are also single and double GTX 1070 SKUs available.)

The Titan Pro's GTX 1080 performed well in our 1080p gaming tests, scoring 76fps in *Total War: Warhammer II*'s battle benchmark, and 61fps in the demanding *Ghost Recon: Wildlands*. It was able to handle the slightly older *Rise of the Tomb Raider* even more easily, scoring an average of 110fps.

As our machine had a 4K screen, so it made sense to test at that resolution, too. At that more demanding resolution, the single GTX 1080 struggled. *Tomb Raider*, the easiest test, returned scores of 53fps in the Mountain Pass, 44fps in Syria and 43fps in the Geothermal Valley, for an average of 47fps — not great. Meanwhile, the more demanding *Total War* and *Ghost Recon* proved even more difficult, with 30fps and 29fps, respectively.

In other words, the single GTX 1080 couldn't maintain 60fps at 4K in any of the games we tested. And if you opt for the 1080p 120Hz panel option that's available, you're stuck with a TN screen. For a machine with these sort of internals, we would have much preferred a high refresh rate 1440p IPS screen — especially at this price point.

The Titan Pro boasts a robust cooling system, featuring MSI's "cooler boost" technology. It certainly succeeded at keeping things cool, but it was incredibly loud doing so. Even after tweaking some settings, the fans made a ton of noise whenever they spun up even a little bit. We had hoped that things would stay quiet during regular gameplay. Alas.

Bo Moore

Verdict

Features ★★★★½
Performance ★★★★
Value ★★★

While gigantic and expensive, it boasts a mechanical keyboard and great cooling. But, boy, is it loud...!

★★★½

$499 | WWW.EPSON.COM.AU

Epson Expression Photo HD XP-15000

Improved colour printing for wide-format prints.

When it comes to printing photos at home, Epson has long been a popular name. More often than not, the company offers excellent results – as long as your creative ambitions don't stretch too far beyond a standard page size.

That's no longer a limitation with Epson's Expression Photo HD XP-15000, which is capable of producing vibrant, wide-format borderless prints up to A3+ in size. Handily, you can print wirelessly from mobile devices as easily as you can from your desktop PC, but unfortunately, there's no EcoTank support (which is a newer Epson technology that eliminates costly ink cartridge replacements).

You can print larger, full-colour pages in about two minutes; standard document printing speeds average nine pages per minute in black and white or colour.

Our initial tests involved printing a large collage using several recent photos taken from our smartphone. Sadly, the Epson Creative Print mobile app hasn't yet been updated to accommodate page sizes larger than A4, although it otherwise worked fine for printing from Facebook and Instagram accounts, stationery, CD/DVD disc labels and even converting images from our photo library into colouring book pages. We wound up using a desktop app to create our collage, which took about three minutes and 40 seconds to print in full colour and at the highest quality setting.

The front tray is capable of holding up to 200 sheets, but the rear 50-sheet tray is where the wide-format action comes into play, along with projects involving card stock or exotic paper types. One unique feature is the motorised front tray, which automatically extends to hold the current paper size. The tray doesn't retract itself once a print has been removed, but you can use the LCD display or a gentle nudge with your finger to close it manually.

Larger paper sizes usually require having an oversized printer, but Epson has kept this model as compact as possible. Measuring 47.6 x 36.9 x 15.9cm with both trays closed, the XP-15000 is 30% smaller than its predecessor.

In terms of print quality, Epson hasn't quite reinvented the wheel here, but colour reproduction and clarity was noticeably improved based on side-by-side comparisons with earlier models. In any case, prints were already of a higher quality than you would get from most alternative photo printing services. All but the most discriminating professional photographers will be pleased with this investment.

The XP-15000 does tend to be louder than earlier models while in use, particularly when making wide-format prints. To combat this, Epson added a menu option called 'quiet mode' that can be toggled on in settings; the trade-off is that prints will take a little longer to output this way, but that's a small price to pay if the alternative is causing your coworkers great ire. ■ JR Bookwalter

Verdict

Features	★★★★½
Performance	★★★★½
Value	★★★★☆

For high-quality wide-format prints, this is a compact, reasonably-priced option.

★★★★½

STYLUS

$50 | ADONIT.NET

Adonit Pro 3

Write on your touchscreen with an analogue stylus.

Adonit's Pro 3 is a passive stylus, requiring no Bluetooth and no batteries. The stylus has a very fine point; to persuade your tablet of choice to recognise this, it's attached by a ball joint to a fingertip-sized plastic disc, which skates across the screen.

It looks weird – but it works brilliantly, and is transparent, so you needn't worry about it obscuring what's on the screen. After a few moments of use, you forget the disc and use the Pro 3 like a ballpoint. The body is slim (at 9mm in dimeter), maybe too slim for big hands, but it's beautifully made. The lid snaps on over the tip with a satisfying magnetic clunk, connecting in the same way to the other end (which has an integral pocket clip) to keep it safe while in use. The grip is textured, which gives it a really nice feel while in the hand, too. It's also quite lightweight at 18g, and 12.6mm long. You can also grab it in four different colours: black, silver, rose gold and midnight blue.

On iPad, we found that while the Pro 3 lacked the precision of the Apple Pencil, and you can't lean your palm on the screen with impunity, it did enable us to work much more finely than with a rubber tip.

It's reportedly compatible with all touchscreens, so you can grab this for your smartphone or whip it out when using your Surface laptop, or basically any iPad or Android tablet.

If you don't want to pay around twice the price for a Bluetooth stylus, and you don't mind the slightly strange-looking tip design on offer here, then the Pro 3 is pretty effective.

Adam Banks

Verdict

As close to a pencil or pen as you'll get for use on any touchscreen device (and without batteries).

USB SOLID STATE DRIVE

$349 | WWW.G-TECHNOLOGY.COM

G-Technology G-Drive Mobile SSD R-Series 500GB

Speedy, sturdy storage.

Like many of the external solid-state drives we've seen since late 2016, the R-Series (R for rugged) adopts a fast USB 3.1 Gen 2 interface. The eye-catching case has an IP67 rating for resistance to water and dust, though there's no cover for the USB-C port. According to G-Technology, the R-Series is drop-proof up to 3m (onto a carpeted concrete floor), shock- and virbration-resistant, crushproof to 450kg and comes with a 5-year limited waranty.

True to its name, the drive's body feels durable. At 86g, it's a little heavier than Samsung's T5 (51g), and if it's office hazards you want to protect against, you don't really need this one's designed-for-outdoors robustness. At 9.4 x 5 x 1.5cm, the R-Series thankfully isn't much different in terms of size to Samsung's offering (at 7.4 x 5.7 x 1.1cm).

G-Technology quotes a maximum transfer rate of 560MB/sec. In our testing, the peak figure was 537.4MB/sec. That makes the R-Series the best (non-RAID) mobile SSD for sequentially reading data that we've tested, and puts it within a whisker of the best for writing – the considerably bigger and heavier CalDigit Tuff currently holds that trophy.

But it's average in tougher random read/write tests; its 366.6MB/sec peak when reading is 46.6 slower than the Samsung T5 and 62.7 slower than the CalDigit Tuff SSDs.

However, it's still a great, slightly tougher option than the T5, and is available in the tested 500GB capacity, as well as the larger 1TB and 2TB options.

Alan Stonebridge

Verdict

A great, fast storage choice with good transfer rates, in a tough but attractive form.

KEYBOARD

$299 | LOGITECH.COM/EN-AU

Logitech Craft Wireless Keyboard

The crown jewel of keyboards comes at a royal cost

Logitech's latest wireless keyboard is one of the best we've ever used, but when you can score premium mechanical workhorses for significantly less, you have to ask is it worth the heavy outlay?

The Craft sports a similar sleek chic minimalism that does so well for Apple, and with construction this sturdy, there's no doubt (aesthetically or ergonomically) that this is a premium device. Although it's not adjustable, the 'board's slight angle makes for comfortable typing, and the low-profile keys with circular indents are the most pleasant membrane caps we've ever danced our fingers across.

Logitech Flow is also included, allowing you to switch to one of three paired Bluetooth devices with a single button press. The battery is rechargeable via USB-C and offers a week of consistent use, thanks in part to the auto-illuminating keys that remain dormant until they detect your fingers. The pièce de résistance, however, is the Crown – a seamless, squat cylinder at the top left of the 'board. This control is context-sensitive, allowing you to adjust volume, scrub through video, or change brush size depending on the software. Twisting the knob switches between smooth or incremental motion, depending on its application, and you can quickly cycle through its configurations with a gentle tap. The future potential for this feature is strong, especially for creatives.

The Craft is an impressive culmination of Logitech's many years of keyboard design. However, for those that aren't going to embrace the Crown, you may be better off going with a (much) cheaper alternative.

Harry Domanski

Verdict

You'd better make sure you'll use its premium features, because they weigh heavy on the price.

★★★★½

KEYBOARD

$210 | WWW.MICROSOFT.COM

Microsoft Modern Keyboard with Fingerprint ID

PC security at your fingertips.

Microsoft has been producing keyboards and mice for decades, but now that it's expanded into the PC-making business, it's become important for the company to maintain a design consistency with its Surface products – particularly the Surface Studio, which Microsoft's new Modern Keyboard with Fingerprint ID seems destined to accompany.

With its sleek aluminium frame and flat, squared keys, the new Modern Keyboard is about as classy as keyboards get. Though the keys themselves are quite close to the metal they're sitting on, there's a nice travel distance, making the Modern quite satisfying to type on. They also have a matte finish, avoiding the cheap, shiny look that many other keyboards tend to have.

However, the real reason you'd probably pick this one up is because of its inbuilt fingerprint sensor, which lets you to securely log in to your PC without having to type out a password or PIN. Microsoft's implementation of biometric security on the keyboard is flawless, with the sensor itself embedded in a key (next to the right Alt key) that looks just like every other one, helping it maintain a level of visual consistency throughout. Fingerprint data is stored on your computer alone, and you can set that up in Windows 10's account settings.

As this is a wireless keyboard, you should get around four months of usage before you need to recharge, which you can do via its micro-USB port. At $210, it's a somewhat pricey unit, but worth it for those who're sick of typing passwords.

Stephen Lambrechts

Verdict

Beautifully designed and smartly realised, though likely be too pricey for many potential buyers.

★★★★½

USB WEBCAM

$159 | WWW.RAZERZONE.COM

Razer Kiyo

A streaming desktop camera for 'serious' gaming influencers.

Razer has made a big, all-in splash in the streaming peripherals market, knowing well that, with the breathtaking rise of YouTube and Twitch video game celebrity culture, everyone's going to want a piece of the action. The Razer Kiyo is a portable webcam which will play nice with both desktops and laptops, with its ability to be both clipped to the top of a monitor or mounted onto a camera stand. It captures crisp images with its 4MP, 2,688 x 1,520-pixel camera and comes with an in-built light (more on that later).

The good news is, if you're not a game streamer (the Kiyo's undeniable target market), this is a very premium and super easy unit to use, and your distant relatives will see you with the kind of clarity that might be a bit uncomfortable.

But the Kiyo's real innovation is its light bar, which fashionably surrounds the camera lense. With this, you can adjust the lighting on your figure by twisting the light itself, a useful touch if you're concerned about looking all moon lit and pasty while streaming *CS:GO*.

Since it's a plug-and-play device, it didn't need any software tinkering, and the widely used (and open-source) OBS streaming application had no problem detecting and using it.

It may be costly, but given how stylish and easy-to-use it is (not to mention that it captures good quality video), Razer's probably cornered the market for aspiring and professional streamers alike.

Shaun Prescott

Verdict

A premium-priced cam that does what it says on the tin.

★★★★½

USB MICROPHONE

$159 | WWW.RAZERZONE.COM

Razer Seiren X

A solid condenser mic with its eyes on the pro streaming market.

Designed to be used in tandem with the Razer Kiyo streaming webcam, the Seiren X is a sleek and, as far as gaming peripherals go, inconspicuous condenser microphone. Like the Kiyo, it's designed as a plug-and-play device, so no fancy third-party software is needed and it played nice with the widely used (and free) OBS streaming software we used to test it. It's a streamlined affair, with a simple volume knob controlling the 3.5mm headphone output, and a mute button which illuminates green or red.

Razer boast of its supercardioid pickup pattern, which it claims "records [input] at a tighter angle" than most condenser mics. And this bore out in our testing: we streamed to a small audience who didn't notice a child yelling in the next room, and getting the right output was as simple as using OBS's inbuilt controllers.

You can pick one of these units up for as little as $150, and while that's still quite pricey for a condenser mic, this one really lends itself to game streaming given its focus on precision recording. It's also designed to be portable, so if your future life as a professional game streamer involves attending LANs or tournaments, this weighs only a bit more than your average smartphone.

We would have liked a retractable pole connected to the mic's base, in order to raise and lower the mic according to usage, but few desktop arrangements will demand this requirement anyway, so it's hardly a caveat.

Shaun Prescott

Verdict

A solid, sleek and streaming-focused mic.

★★★★½

MECHANICAL GAMING KEYBOARD

BLUE SWITCHES, $189; SILVER SWITCHES, $199 | THERMALTAKE.COM.AU

Thermaltake X1 RGB Gaming Keyboard

Big, heavy and blisteringly quick.

Thermaltake has been quietly beavering away making affordable and genuinely great gaming keyboards for a long time now – the Poseidon Z is a particularly fine example – so in unboxing the more premium-priced X1, we were expecting great things.

Out of the box, the first thing that struck us is just how heavy the X1. Weighing a cookie under 1.6kg and at 46 x 17cm, this is a robust slab of key-bejewelled metal that takes a commanding amount of real estate on the desk, even without the wrist rest. The X1 comes in two Cherry mecahnical switch flavour options; Blue or Silver (which costs 10 bucks more). Our review unit was fitted with the latter – and we were so enamoured, we reckon these'll be our go-to switches from here on out. With a 1.2mm actuation and 3.4mm travel combined with no physical pressure point, the Cherry Silvers are super quick, and as long as you're not a rage gamer, super quiet. Key spacing here is also spot-on, making banging out paragraphs comfortable.

You also get headphone and USB passthrough (keep in mind the X1 will eat two USB ports on your PC to utilise this feature) and media controls – including a very Corsair K-series volume scroller. A nice touch is the included pack of red replacement keycaps for the core gaming WASD nesting, although this does muddy the backlighting in that region just a touch.

The X1 also *boasts* its own mobile app which allows users to switch macro sets on-the-fly. You can control lighting colours and pre-configured modes from the app... with your voice, which absolutely no one needs to do that. Ever. ■ **Troy Coleman**

Verdict

A flashy and premium gaming board with Silver switches for impressive speed and durability.

★★★★☆

BLUETOOTH GAMING HEADSET

$229 | WWW.HYPERXGAMING.COM

HyperX Cloud Flight

A pricey plug-and-play powerhouse for PC and PS4.

I've always used headphones for gaming. No exceptions. But finding something flexible enough to move from the close confines of my rig to the comfort of the couch has proved to be a grail quest.

HyperX's Cloud Flight tries to provide part of the answer, offering out-of-the-box wireless audio and comms for both PC and PS4.

Setup is a simple matter of plugging in the USB Bluetooth dongle included in the pack, then digging into your device settings to direct the audio to the headset (the same goes for your outgoing mic if you're into chatting,raging, raid leading) and you're good to go. The look and feel of the Cloud Flight is at odds with the price tag, however. It's an all-matte plastic affair with not-so-luxurious cusion coverings that doesn't match the other offerings in the Cloud range, which sport metal frames and woven cusion coverings. You're paying a premium for Bluetooth, which really kinda sucks. But at least the Flights are comfortable; there's plenty of adjustment points in the design to fit a variety of scones and the 300g wears lighty.

Sonically, they're perfectly adequate, proving strong in the bottom end and losing momentum as it rises through the range. The soundscape and directionals are decent for closed-back cans. Battery life is also important in a Bluetooth headset with the Flights offering up to 30 hours with the side LEDs switched off, and half that time with them on. (No points for guessing which mode we used.) Thankfully, there's a 3.5mm backup cable if the battery dies from too much LEDing. ■ **Troy Coleman**

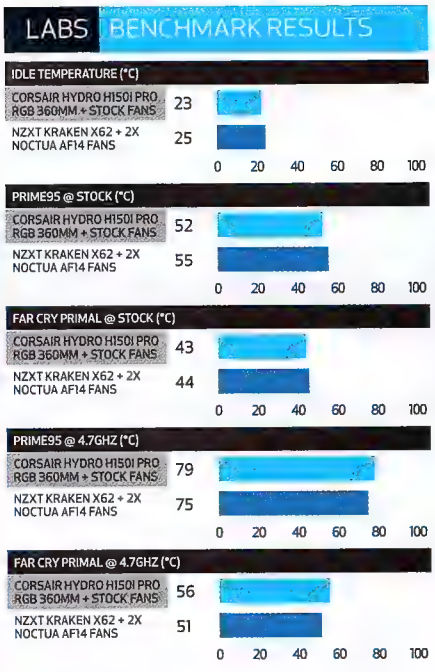
Verdict

Handy for PC and PS4 comms, but they're too expensive for just average build-quality and audio.

★★★☆☆

LIQUID COOLER

$259 | WWW.CORSAIR.COM


LABS BENCHMARK RESULTS
IDLE TEMPERATURE (°C)
CORSAIR HYDRO H150I PRO RGB 360MM + STOCK FANS 23
NZXT KRAKEN X62 + 2X NOCTUA AF14 FANS 25
PRIME95 @ STOCK (°C)
CORSAIR HYDRO H150I PRO RGB 360MM + STOCK FANS 52
NZXT KRAKEN X62 + 2X NOCTUA AF14 FANS 55
FAR CRY PRIMAL @ STOCK (°C)
CORSAIR HYDRO H150I PRO RGB 360MM + STOCK FANS 43
NZXT KRAKEN X62 + 2X NOCTUA AF14 FANS 44
PRIME95 @ 4.7GHZ (°C)
CORSAIR HYDRO H150I PRO RGB 360MM + STOCK FANS 79
NZXT KRAKEN X62 + 2X NOCTUA AF14 FANS 75
FAR CRY PRIMAL @ 4.7GHZ (°C)
CORSAIR HYDRO H150I PRO RGB 360MM + STOCK FANS 56
NZXT KRAKEN X62 + 2X NOCTUA AF14 FANS 51
0 20 40 60 80 100

Corsair Hydro H150i Pro RGB 360mm

The sound of silence.

When it comes to thermal dissipation for clean builds, ridiculous efficiency and noise reduction, AIOs are the way forward. Those early teething days are long gone.

That said, maximum core counts have almost doubled in the last year alone, so the need for more powerful cooling solutions has grown, and although this isn't the first time we've seen a triple-rad AIO, it's the first we've seen from Corsair, and one that isn't based around Asetek's rather aggressive patenting at that.

Aesthetically, the Hydro H150i Pro RGB is a whole different beast from the now-legendary 'old-school' H100i we used to know and love. The design, bezel, fans, lighting have all been redeveloped from the ground up around the industry's obsession with RGB. Not that it's entirely a bad thing. The Hydro's appeal lies within the small details Corsair has integrated into the unit. Whether it's the aluminium-flecked logo embedded into the side of the rad, the braiding covering the tubing between the block and the radiator, or the RGB-lit block itself, it all combines to make an exceptionally clean-looking piece of hardware. Almost.

It's that octagonal block that is arguably the most divisive part of the mixture, with the stark silver of the thick bezel standing out a bit too much for our liking. But let's face it, designing a cooler that doesn't encroach on the competition's style, yet is still decisively a Corsair product, is a challenge, and there are limited things you can do with a waterblock – so we understand that those designer decisions are pretty slim pickings right now.

The real beauty of the Hydro H150i Pro RGB, however, lies in the cooling – or rather, the very obvious lack of noise associated with said cooling. It's the fans. Corsair has upgraded the stock fans usually included with AIOs, using a set of three ML120 maglev variants (some of our favourites) instead. Combine that with the addition of a zero-RPM fan mode in the Corsair Link software suite, and fan noise can be reduced to an absolute minimum with ease, with the fans only kicking in when the CPU reaches a temperature of your choosing.

Corsair's Hydro H150i Pro RGB is a fantastic addition to this mammoth company's arsenal. It's just that the CPU block is going to be so divisive, especially among people who prefer the sleeker, more professional designs associated with Corsair's Graphite series of cases and more. What we'd love to see in the future is a way of replacing that bezel with potentially different coloured frames, or perhaps a sleeker block entirely, integrating Corsair's love and talent for RGB, while retaining the Graphite's serious sensibility.

All that said, if you've got the space for it, and are after the quietest AIO on the market, the Hydro H150i Pro RGB is the perfect fit for any silence-loving, cool-craving PC tinkerer.

Zak Storey

Verdict

Features	★★★★½
Performance	★★★★½
Value	★★★★

Solid fans, good performance and an intuitive mounting mechanism. Divisive CPU block design, though.

★★★★½

software

» APPS FOR ALL THE PLATFORMS

Windows SOFTWARE

GameMaker Studio 2

Make games — with or without coding.

FROM US$39–$1,500 | YOYOGAMES.COM

Some great games have been produced in previous versions of GameMaker Studio, including *Hyper Light Drifter* and *Spelunky*. GameMaker Studio 2 is the latest incarnation, which its developer says has everything you need to take your idea from concept to finished game, with supposedly no barriers to entry.

Starting a new project presents you with two options. Drag and Drop is a visual scripting tool, which can be used to create games without typing code. You are still programming, but your code is created and presented visually using 'blocks', visual representations of simple expressions or statements, such as loops, which fit together in sequence. In theory, a whole game could be put together this way and is great for absolute beginners, especially since you can view the underlying code to see how it's all done.

Intermediate and experienced developers will want to try GameMaker Language, which is designed to give you the power of other programming languages, while still being relatively easy to learn. Typing directly into GameMaker Studio's code editing window allows for much faster progress, and this version's editor offers much improved code completion, filling in function names as well as any variables you've created to record the state of objects and colour-coding them all appropriately.

If ever you get stuck, you can turn to the documentation or watch one of YoYo Games' many instructional and informative YouTube videos.

A nice feature for coding on the go is GameMaker Studio 2's Laptop Mode, which changes the layout and interface interactions in subtle ways, utilising your smaller working area and making working on a laptop much less of an impediment.

It also includes image editing capabilities, animation tools and a visual level editor, which is much improved over the previous version. The tile editor allows you to draw out the floor plan of your level, almost like using a paintbrush.

Every feature in feels like the developer has tried to address the usual pain points in game development. The range of tools and ease of use of GameMaker Studio 2 mean that it really is for everyone. **Gary Riches**

TinyWall

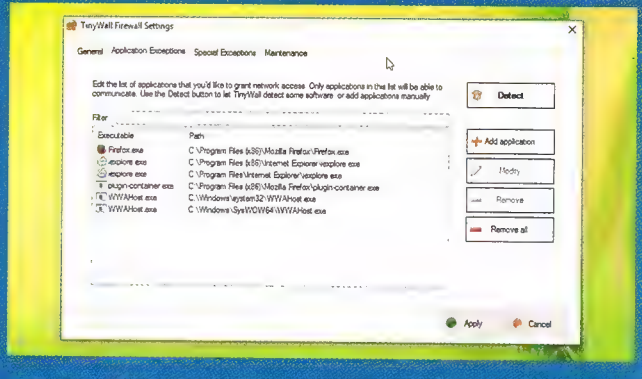
Simplify your firewall security

FREE | TINYWALL.PADOS.HU

Windows has had its own built-in firewall since Windows XP, but while its security has been sound in recent years, it's not particularly easy to find or configure and there's malware out there that knows how to turn it off altogether.

TinyWall is designed to build on the existing Windows Firewall system to address some of these shortcomings. It starts off with a much more secure default configuration, and gives the firewall a much simpler user interface that makes it easy for anyone to decide which settings to adjust.

If overly-chatty firewall apps drive you crazy, you'll appreciate TinyWall's approach: rather than bother you with every single thing it discovers, it automatically blocks known baddies and doesn't use a single popup. Approving new apps is fast and straightforward, and it also offers some advanced features such as time-based rules and blocklists.

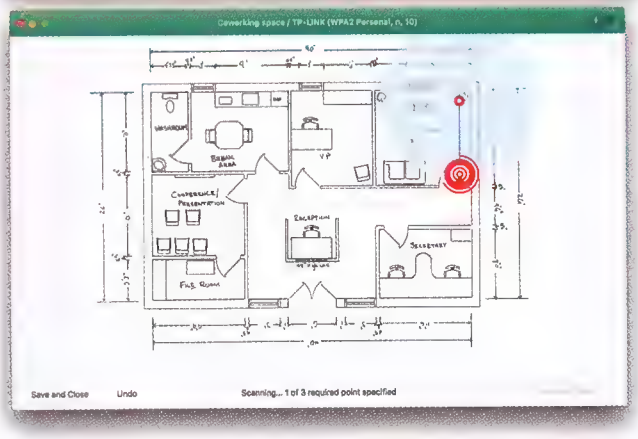


Best of all, TinyWall introduces a really straightforward way of adding new apps to the approved list and if you want to expedite this, you can use a simple hotkey combination. **Gary Marshall**

Wifiner

Visualise your Wi-Fi.

$46.99 | NETSPOTAPP.COM/WIFINER



Few of us pay attention to placement of a new wireless router, never realising that location is everything. Wifiner allows anyone to visualise the layout of a wireless network and identify potential trouble spots.

Essentially a simplified version of the more robust NetSpot app, Wifiner samples Wi-Fi coverage as you move around home or office manually marking points, then generates a 'heat map' displaying wireless signals as a rainbow of colours ranging from weakest to strongest.

You can switch between 11 different views to show, for example, signal-to-noise ratio, upload or download speed, and areas where high levels of noise are present. Such visualisations are handy for identifying areas with spotty reception. Beyond exporting PNG files of the selected view, however, the app offers little guidance for fixing problems.

Although Wifiner works on desktop Macs, it's really designed for moving around. You'll also need an existing floorplan scan; otherwise new surveys are created using generic sample maps.

It's a neat way to create Wi-Fi visualisations, but with little guidance, and no troubleshooting help it won't be for everyone. **JR Bookwalter**

Printopia 3

Easy printing for iOS.

US$19.99 | DECISIVETACTICS.COM

In the days before AirPrint, Printopia was about the only way you could print directly from an iPhone or iPad. If you don't have an AirPrint-compatible printer, it's still one of the easiest options for getting iOS documents onto paper.

Previously a System Preferences pane, Printopia is now an app in its own right, but it doesn't have to be running in order to print from an iOS device. You don't even have to be logged in on the Mac on which it's installed. As long as the Mac is switched on and connected to the same network as your iPhone or iPad, you can simply tap an iOS document's share sheet and then tap Print to send to any printer that your Mac can print to. An additional option, Send to Mac, is still a quick and easy way to transfer files.

You can configure multiple printers in groups — there's a Pro version (from US$99) to administer more than five.

One glitch we noticed: If you've enabled printer sharing on your Mac, there can be a conflict between two identically-named versions of a printer (one macOS, one Printopia). The workaround is to change the printer's name in Printopia.

Printopia is excellent for printing from an iOS device without AirPrint. **Kenny Hemphill**

Bartender 3

Take back control of your menu bar.

$19.89 | MACBARTENDER.COM

Bartender is so clever, you have to wonder why Apple hasn't integrated its features into macOS itself. It enables you to control what appears in the menu bar and when. You can hide icons permanently, relegate them to the secondary Bartender menu, or let them temporarily appear when they update. You can also drag and drop menu items within the menu bar to rearrange them.

Configuration is handled via the app's own System Preferences pane, which is both comprehensive and easy to navigate. Version 3 is largely a major compatibility update — rewritten from the ground up to play nicely in Sierra and High Sierra. It means you can once again control system items on the menu bar without attracting the unwanted attention of System Integrity Protection.

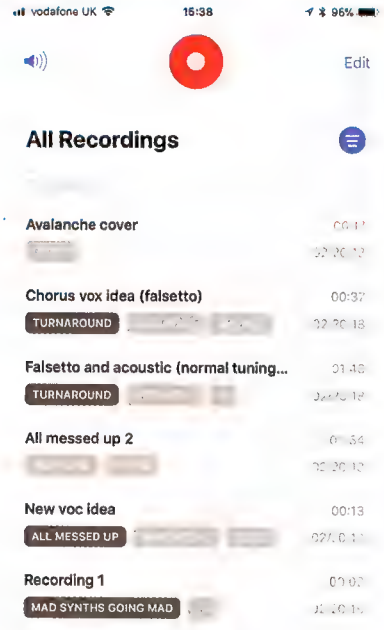
That said, there are some new features, too. The interface has been updated so the Bartender Bar overlays the menu bar when evoked instead of appearing beneath it. There are also two new keyboard hotkeys for searching and navigating the menu bar without using the mouse.

Bartender 3 remains the go-to app for those wishing to tame their menu bar. It's a must-have. **Nick Peers**

AudioFile — Voice Memo Notes

Audio notes with extras.

FREE | STEPHENMORR.IS



AudioFile is a cross between Apple's own Voice Memos and Notes apps. It enables you to record audio, tag the recordings, and include text and images. This makes it particularly useful for musicians, who can record their latest musical idea and then take a shot of a particularly tricky chord, or their pedal setting or keyboard patch, or of their scribbled lyrics. And they can use the text field to record information such as key, tuning, and tempo.

However, the app is just as useful for anybody who might want to supplement a spoken note with an image or accompanying text, such as interviewers, students or spies. Files are classified in three ways: by name, project and tags. For example, you might have a project called 'Field Trip' and then create tags for different parts of the project, or create a project for a class and have tags for the different topics covered in that class. The value of such tags is discovery: The app enables you to search for a specific tag or tags (provided, of course, that you've used them in the first place). AudioFile doesn't do much, but what it does do, it does very well. It's lightweight and fast, easy to use, and will quickly locate exactly what you're looking for. **Carrie Marshall**

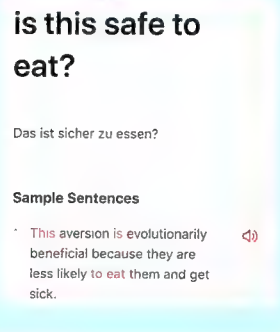
U-Dictionary

"Words, words, words, I'm so sick of words!"

FREE | WWW.U-DICTIONARY.COM/HOME

Offline

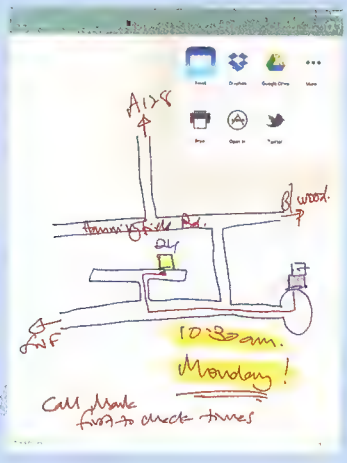
U-Dictionary is as useful as you need it to be. Dictionary, translator, English language learning device... It's primarily an app for English-as-a-second-language users, but that's not to say you can't use it if you're a boring native English speaker, like us. If you need it to be a simple translation device, it can do that easily for 38 languages, providing you with contextual sentences including the word you're looking up or a translation of a whole sentence. If you want it to help you speak English, it has planned tests and conversations you can practise. If you want to brush up on your English vocab, it has a variety of ways to help you do that, too. There are groups to discuss certain topics or words. And lots of videos. Does it suffer from trying to do too much? That's hard to say, but the interface could probably use some work. In order to find out what the app can do, you have to scroll down through all the different activity types, rather than see them all in a dropdown menu or hideable sidebar. So it's potentially very useful, if you can find what you're looking for. **Carmel Sealey**


is this safe to eat?
Das ist sicher zu essen?
Sample Sentences
This aversion is evolutionarily beneficial because they are less likely to eat them and get sick.

Noteshelf 2

Can it rival Apple's improved Notes?

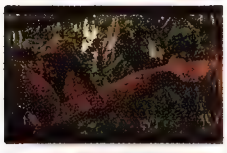
$14.99 | NOTESHELF.NET



Noteshelf 2 has tools for marking PDFs, lets you add photos, and handles typed and handwritten notes. However, there is a limitation to the handwritten content. You get a choice of two pen tools, a pencil, a highlighter and intelligent shape tools. It can even record audio as you jot or type, although you can't link your jottings to locations within the soundtrack. Noteshelf 2 lacks the handwriting recognition of the native Notes app, so you can't search entries with Spotlight, and when you export a handwritten page, it will transfer as a PNG or PDF. If you want to export in a more usable format, try Nebo. Notes are synced between iOS devices through iCloud, but there's no macOS version. The app also integrates with third-party cloud services like Dropbox, Evernote, Google Drive, OneDrive and Box. Version 2 introduces numbered lists, bookmarks, bullets and checkboxes, and you can now group notebooks. There are three new paper sizes — A4, 'mobile' and 12.9-inch. Noteshelf 2 is affordable, but it's missing a couple of features. Its compatibility with Evernote and other third-party cloud services is tempting, and plugs the gap of a missing macOS edition, but there are more flexible options if you look around.

Nik Rawlinson

850 METERS.mp4
1min 1280x720


Amazonia.mp4
2min 1280x720

Big Buck Bunny.mov
9min 1280x720

Big Hero 6.mp4
2min 1280x720

Le vent se lève.mp4
1min 1280x720

Mad Max Fury Road.mp4
2min 1920x1080

VLC

The media player mainstay keeps improving.

FREE | WWW.VIDEOLAN.ORG

You might wonder why we're reviewing one of the most enduring cross-platform media players now, since it's been available on Android for years. But it's received plenty of updates throughout its life, and it's worth returning to.

For the fundamentals (ie, playing a large selection of video file types in an easy-to-use UI), VLC is still hard to beat, and remains one of the first apps installed on any new device. Chief among the recent updates though is Chromecast support. While it's still in beta (though easily accessible through the publicly available app), this allows you to stream VLC to your Chromecast device, which for some might prove a more convenient way to get phone content playing on a TV.

Meanwhile, scrolling through videos has been improved – it's not as choppy as previously – and local network file sharing is as simple as selecting the relevant local device and entering a password. **Shaun Prescott**

Vue

Montage maker.

FREE | VUEVIDEO.NET

Do you have a video or 20 of your cat, stashed on your phone? Of course you have. Or maybe of your, or a family member's, baby doing something cute? Perfect. Vue can stitch them all together easily and simply, with a good selection of Instagram-esque filters and movie-like transitions.

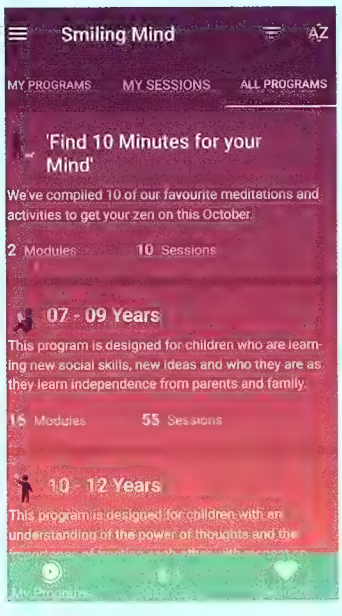
It promotes itself as a montage creator, producing videos that last as little as 10 seconds all the way up to three minutes. You can have as little as one continuous shot in your video, or as many as you care to throw in. Exceptionally well designed and easy to use, whether you're loading in pre-existing videos or filming on-the-fly, videos can be adorned with captions, emojis, location and weather data. Wrap up shooting, and videos will be saved to your phone as an MP4 with the option to share them to social media or upload to cloud storage. Remarkably, it's totally free as well, and the Vue watermark is small and unobtrusive in the bottom right hand cover of the video.

Paul Taylor

Smiling Mind

Meditate without stressing about your money's worth.

FREE | SMILINGMIND.COM.AU


Smiling Mind
AZ
MY PROGRAMS
MY SESSIONS
ALL PROGRAMS
'Find 10 Minutes for your Mind'
We've compiled 10 of our favourite meditations and activities to get your zen on this October.
2 Modules
10 Sessions
07 - 09 Years
This program is designed for children who are learning new social skills, new ideas and who they are as they learn independence from parents and family.
15 Modules
55 Sessions
10 - 12 Years
This program is designed for children with an understanding of the power of thoughts and the

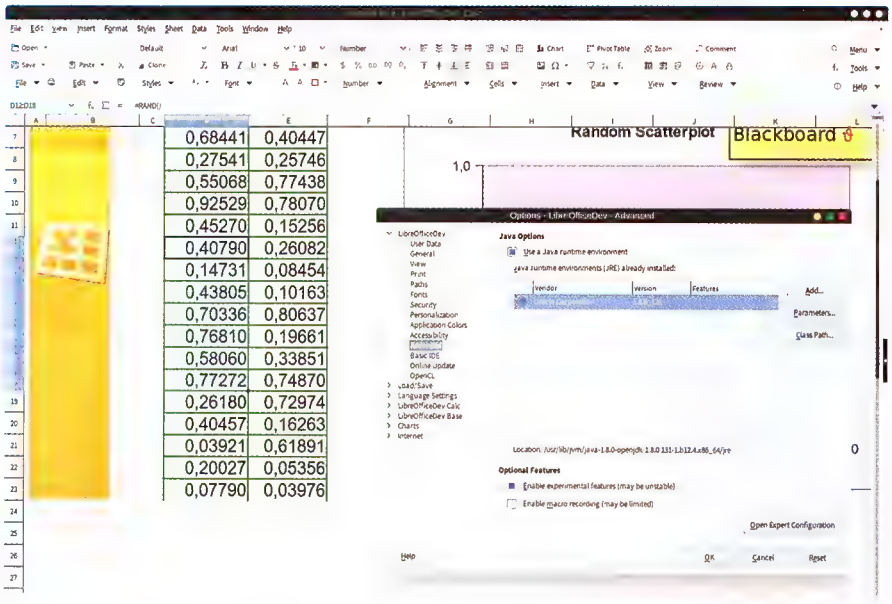
There are a lot of meditation apps available on Android, but Smiling Mind differs from most of them in two key ways. First, it's completely free, which is refreshing when rivals like Headspace and Simple Habit require monthly subscriptions to access most of their material. Second, Smiling Mind is aimed at children as well as adults, with a range of meditation courses available for different age ranges, starting at 7–9 years. It even includes lesson plans and activities for educators trying to teach meditation. If you're not a kid or an educator, there are plenty of other plans that might appeal, from meditation basics, to programs focused on everything from digital detoxes to improving your productivity and sporting skills. There are a mix of audio and video meditations of varying lengths, you can set up sub profiles so multiple family members can all use the app, and you'll see your progress over time, with stats and charts showing how long you've spent meditating, how many sessions you've done and on which days.

James Rogerson

Libre Office 6

A full office suite for zip.

FREE | WWW.LIBREOFFICE.ORG



LibreOffice is the world's most popular and widely adopted open-source set of essential office applications, and its name carries weight well beyond the Linux ecosystem. The more observant among you will have noticed home-printed notices and adverts posted around the neighbourhood that feature the distinctive Liberation Serif font – which is the default one in LibreOffice Writer. It's just one of the everyday pointers that indicate the tremendous popularity this office suite has gained in recent years.

The new release includes a raft of welcome features and updates. Perhaps the most talked-about visual change is the Notebookbar. It first made an appearance back in 2016, but now more than ever, is reminiscent of the Ribbon in Microsoft Office. To start using this new toolbar layout and the View menu you'll need to go to 'Tools > Options > Advanced' and check the 'Enable experimental features' option.

Apart from user interface experiments, there's plenty more to enjoy. LibreOffice now sports full support of OpenPGP keys that can be used to sign ODF documents on any desktop platform. The OOXML interoperability has been improved, which means that various small features now work better when you convert your ODT file to DOCX and vice versa. Embedded objects, cross-references, MailMerge fields and forms have always been a headache, but now they should work much better.

The other new feature that hasn't seen much light (undeservingly) is the 'Grammar by' model for Hunspell. The grammar check function can now automatically recognise new versions of a word formed with affixes or compounds. Previously, you had to add each form of an unknown word to the LibreOffice dictionary manually.

We heartily recommend that you check out the shiny, new LibreOffice 6.0. It works great and looks fresh, and also includes the icon theme that matches the ElementaryOS style. Note that the new KF5 integration plugin for Qt5 is still experimental and, as we write, hasn't shipped yet.

Alexander Tolstoy

Dosbox-X

Emulator for 1990s apps.

FREE | BIT.LY/DOSBOX-X

There was a time when we almost dared to include a Dosbox review here in the Linux Software section, but finally put the idea to one side because Dosbox hadn't been updated since 2012, and it really looked like the project had frozen in time.

However, no one could ever label Dosbox as a classic example of abandonware, because millions of users still run this great emulator to play retro games and launch ancient DOS apps. We were extremely happy to come across Dosbox-X, a revived and extended Dosbox fork with more features and more love for older apps from the 1990s.

The project's goal is to provide a more accurate hardware emulation, ensure there's an accurate historical preservation of what used to dominate the MS-DOS market in days gone by, and to provide a working environment for retro coding. Dosbox-X isn't limited to DOS only, it also supports Windows 3.11 and Windows 9x included Windows ME, which makes it work like a virtual machine (no need to fire up Virtualbox in order to run ancient Windows versions and games for it).

When you start working with Dosbox-X, it feels like a continuation of the old Dosbox software. The new Dosbox-X supports the same config file syntax as its predecessor, and looks practically the same, too. If you're new to both, don't overlook the official Dosbox 0.74 manual that comes bundled with Dosbox-X and contains useful commands and tips that enables you to mount your Linux directories as DOS drives, connect older input devices and much more.

By default, Dosbox-X doesn't use any configuration file, so you'll probably need to set it up manually. Type the following inside the DOS shell:

```
CONFIG.COM -all -wcd dosbox.conf
```

Now you'll have a sample config file in your current Linux directory. Tell Dosbox-X to read settings from there:

```
$ dosbox-x -conf /path/to/dosbox.conf
```

And you're done. Happy retro gaming and coding!

Alexander Tolstoy

SPEED UP WINDOWS 10

Give your machine a much-needed burst of speed with this collection of tools for tweaking, optimising and reinstalling Windows.

When it comes to outright speed, your PC never seems to have enough of it. Or to put it another way, it doesn't matter how smoothly it's running, your PC could always do with being that bit faster. Armed with the right know-how, you can fine-tune your PC to squeeze more performance from it, but the effort involved can be more than it's worth.

Which is where we come in. In this feature we've dug out 20 of the finest free tools we know that can help speed up your PC. We'll open by revealing lightweight alternatives to the bloated apps you've been using, and then we'll move on to reveal our favourite tools for fine-tuning your system. Your hardware could use some optimisation too, so we've collected the best overclocking and tuning apps for pushing it beyond its limits. Finally, when you next time to bite the bullet and reinstall Windows, we reveal free tools that can help safeguard and speed up the process before running you through the steps you need to take to restore Windows to its pristine like-new form, unencumbered by bloated apps and collected detritus.

Your computer is ready to take its performance to the next level with the help of our essential apps. Turn the page to get started with giving it a much-needed boost of speed.

Lightweight apps

Free up RAM and other system resources to help keep your PC running smoothly with these five alternatives.

One of the downsides of the rapidly evolving computer market is that specifications have improved so fast that application makers have rarely felt the need to streamline their programs. Why spend time cutting back the fat when next year's PC will likely be twice as fast anyway?

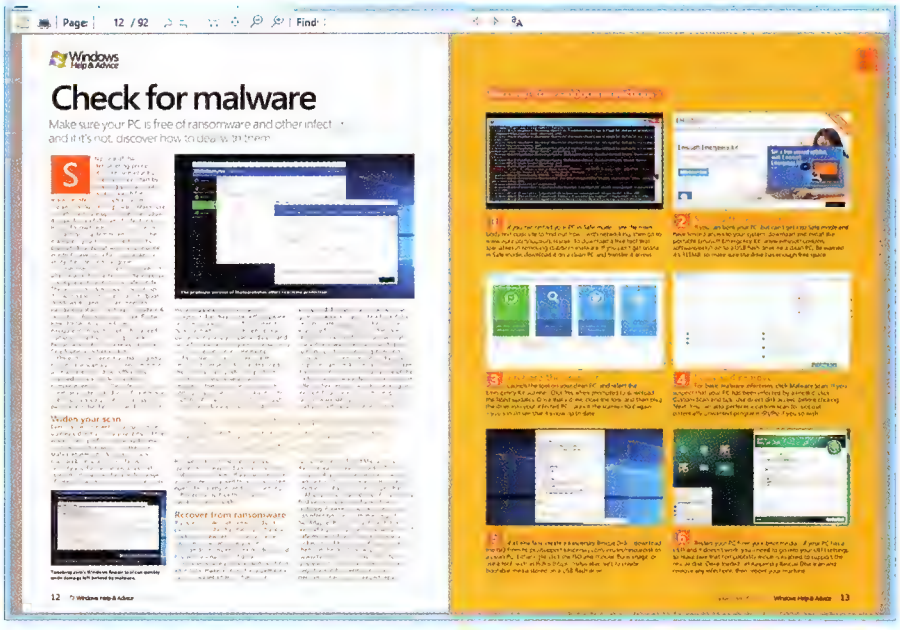
That's fine if you've just bought a shiny new PC, but most of us like to keep our machines running for several years. Or perhaps you bought an entry-level laptop or 2-in-1 only to find 1GB RAM doesn't go half as far as it used to. Before you know it, opening Office or running your image editor seems to sap your PC of its strength, leaving it sluggish and barely responsive.

In this first section, we've identified five key apps that can bring Windows to its knees and dug out lightweight alternatives. Throw away Office, Photoshop and your bloated security tool and try these alternatives instead. They all make fewer demands on your PC's RAM and are engineered to work efficiently and smoothly, even on older and lower-powered machines.

WPS Office Free

Available from **www.wps.com/office-free**, this productivity suite is the perfect lightweight alternative to Microsoft Office. The free version replaces Word, Excel and PowerPoint, and in addition to preserving the Office ribbon, it has some neat tricks of its own, such as multiple document tabs, enabling you to easily switch between two or more documents. There's seven-day version history for all the files that you create with it, enabling you to roll back easily. Plus there's a drag-and-drop tool for adjusting the layout of individual paragraphs in your documents.

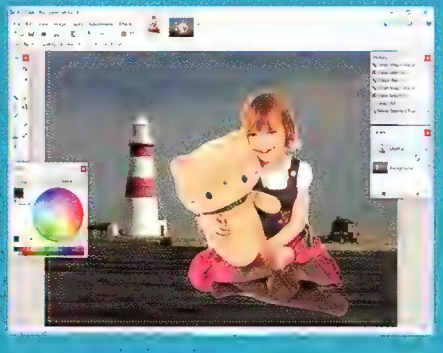
Crucially, WPS Office Free has a small footprint, too, consuming noticeably less memory than Microsoft Office, and there's even a PDF to Word tool that can convert documents of up to five pages. The free version is ad-supported, but they're not too intrusive.


Windows Help & Advice
Check for malware
Make sure your PC is free of ransomware and other infect
and if it's not, discover how to deal with them
Widen your scan
Recover from ransomware

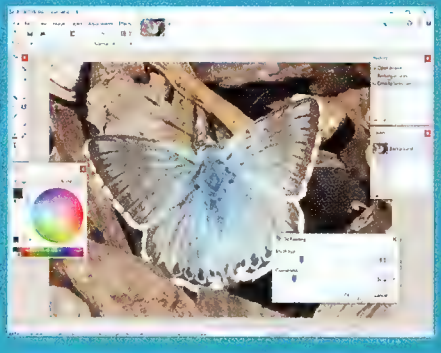
Faster, leaner image editing for free

Paint.NET (**www.getpaint.net**) sits beautifully in the middle between Photoshop (too powerful and bloated) and Paint (too basic), offering the best features of the former without bringing your PC grinding to a halt.

In addition to the standard editing, compositing and colour-correction tools you'd expect, Paint.net also includes some powerful and useful options, too.



1 MULTIPLE LAYERS
Multi-layered images enable you to lay parts of one image on top of another for all kinds of creative effects. Paint.NET has full support for layers, with a transparency slider and choice of methods for blending one layer into another for the perfect image.

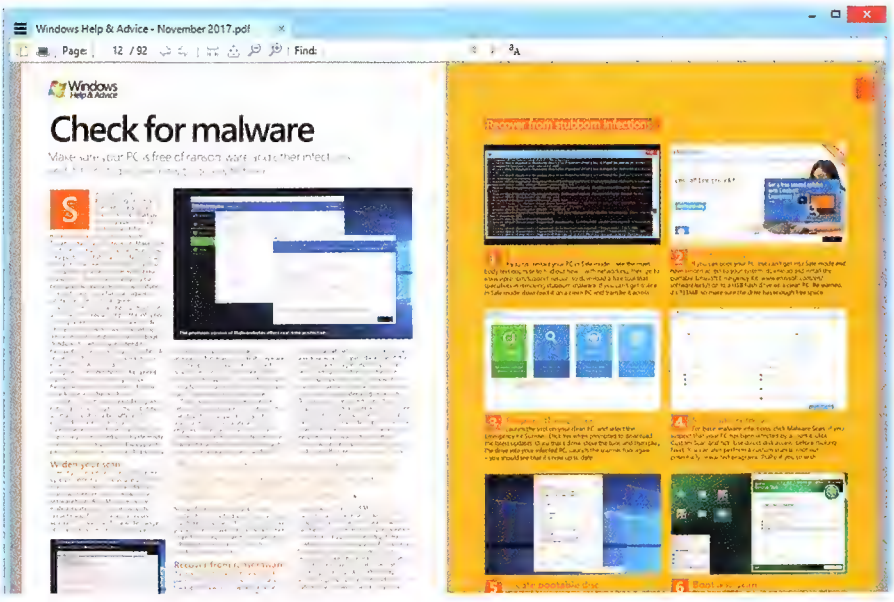


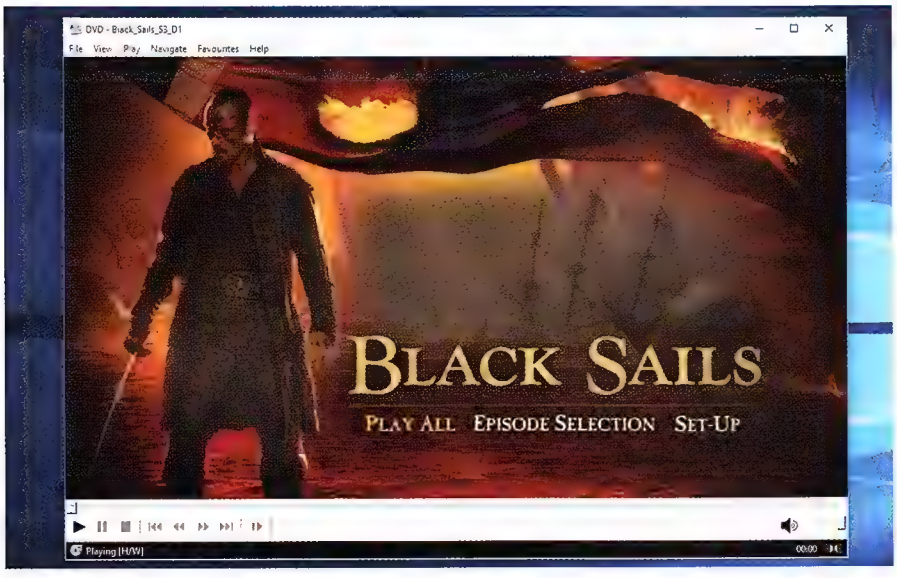
2 POWERFUL FILTERS
Want to do something artistic with your photos? Paint.NET has built-in filters that offer a range of artistic effects, including rendering your photos in pencil, ink or oil paints. Other filters produce blurs, sharpen and distortion effects just like Photoshop.

SumatraPDF

Looking for the lightest, fastest way to view PDF files outside your web browser? Sumatra PDF (**www.sumatrapdfreader.org**) takes up just 5MB of RAM and can read several eBook formats — including ePUB and the Kindle-friendly MOBI — too.

It's lacking in features — you can't create PDFs from other files, for example — but because it's available in portable form, it's worth adding to your toolkit so when you want to read, search or print a PDF or other eBook file, you can save time and use this. Should you need more features, install Foxit Reader (**www.foxitsoftware.com/pdf-reader**) — in fact, why not run both side-by-side with SumatraPDF your default reader, using Foxit only when you need features such as creating PDFs from other documents?

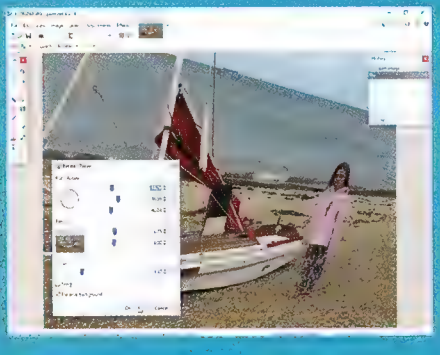


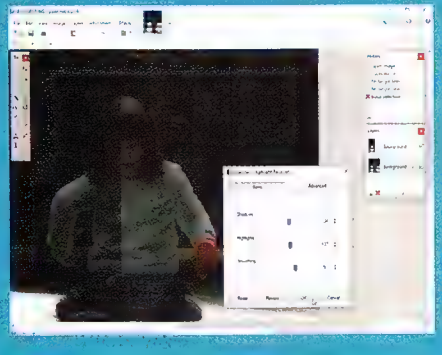


MPC-HC

One area where your computer can be brought grinding to a halt is when you fire up your media player. MPC-HC (**mpc-hc.org**) isn't just a lightweight media player capable of playing a wide range of video formats, it can play DVDs and some Blu-rays, too. It's not short on features either: a Favourites menu enables you to create shortcuts to frequently watched films; you can apply various filters to improve playback quality; and it supports subtitles. It even supports video capture devices, so you can stream digital TV from a compatible tuner.

While you can play music through MPC-HC, we recommend the similarly lightweight and easy-to-use MusicBee (**getmusicbee.com**).





3 3D ROTATE/ZOOM

Want to recompose your image? Select 'Layers > 'Rotate/Zoom...' You'll find sliders for zooming, panning and rotating your picture in both 2D and pseudo 3D. Tick 'Preserve background' to try and fill in the backdrop when 'rolling' in 3D.

4 PLUG-IN SUPPORT

Paint.NET also includes support for hundreds of specially designed plug-ins – visit **www.getpaint.net/doc/latest/InstallPlugins.html** for details. These add extra filters and tools, such as Photoshop file support and a Shadow/Highlights recovery tool.

Bitdefender Antivirus

If your PC is creaking under the demands of your bloated security package, or you're looking to protect a low-powered device like your Windows-powered 2-in-1 tablet, then Bitdefender Antivirus (**www.bitdefender.co.uk/solutions/free.html**) has your back. Better still, its lightweight interface and minimal demands don't come at the expense of protection — it regularly scores highly at AV-Test.

Tune up your system

Discover how to streamline your PC for an extra burst of speed with the help of these powerful — and free — apps.

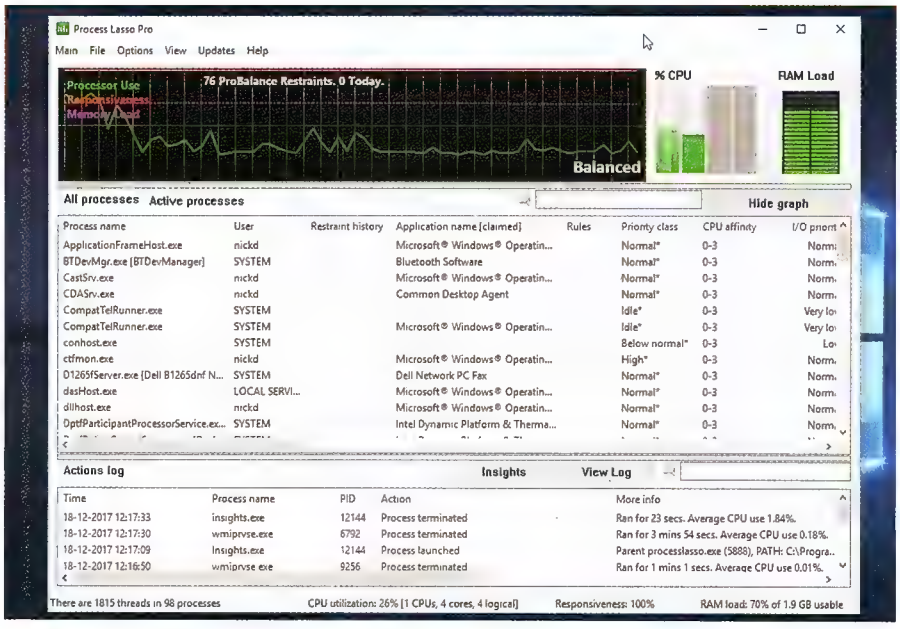
Windows has been designed for maximum compatibility, which means that, while it'll run on a wide range of PCs, it's not been particularly optimised for any of them. This is where the selection of apps in this part of the feature come into play. They give you the tools required to speed up your PC in several different ways. As is usually the case with apps, less is more — there's no point recommending 100 apps whose combined demands outweigh the benefits of using them in the first place, which is why we've pared this down to five apps.

You'll find our favourite tool for managing startup, enabling you to both monitor and improve the way Windows loads. If you're frequently blighted by lockups, then Process Lasso will keep those runaway programs in check. There's also a safe tool for tweaking low-level Services to free up more system resources, JetBoost for temporarily halting unnecessary processes when running games or other demanding applications, and a handy defrag tool to build on Windows' own.

Process Lasso

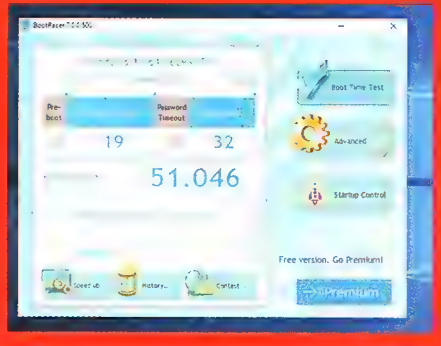
If your machine frequently appears to stop responding or grinds to a halt momentarily, then the culprit is usually a program or system process that's making excessive demands on your system to the detriment of the dozens of other running programs and processes, including Windows itself.

This problem is particularly acute on older or lower-powered PCs with 2GB of RAM or less where there's less memory to go around. Process Lasso (**bitsum.com**) is designed to monitor your PC's processes — when it detects one making runaway demands, it reins it in by temporarily lowering its priority to ensure your PC keeps running smoothly. The free version includes all the core functionality, or upgrade for more features: a lifetime single user licence for the Pro version costs $44.60. Home Pro ($56.97) covers every PC in your home.

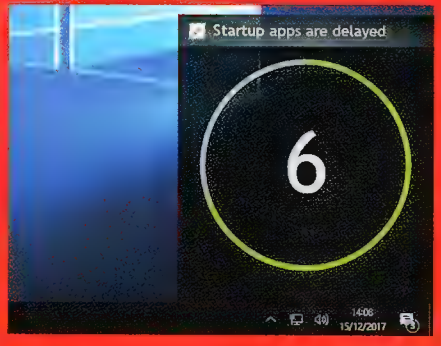


Monitor and improve Windows startup...

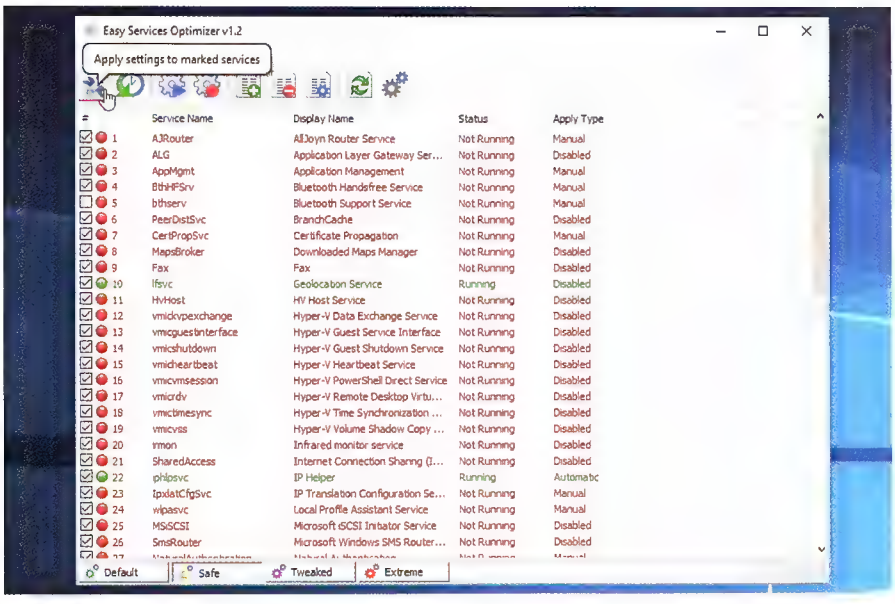
Bootracer (**www.greatis.com/bootracer**) has become our go-to app for managing startup. Not only does it enable you to see which programs are launching with Windows, it times everything too, enabling you to keep an eye on the boot process and giving you a heads up should some resource-sapping program suddenly insert itself into the start-up process. Here's a quick rundown of its key features.



1 TIME YOUR START
The first thing BootRacer does is measure your start time from the moment your PC is switched on until your start-up apps finish loading. This helps you identify bottlenecks at different points of the process, so you can target your troubleshooting.



2 DELAYED START
BootRacer also inserts a delay of 10 seconds to the start-up process to give Windows a chance to finishing loading before any start-up programs are launched. This helps stop your PC from being overwhelmed by demands for system resources.



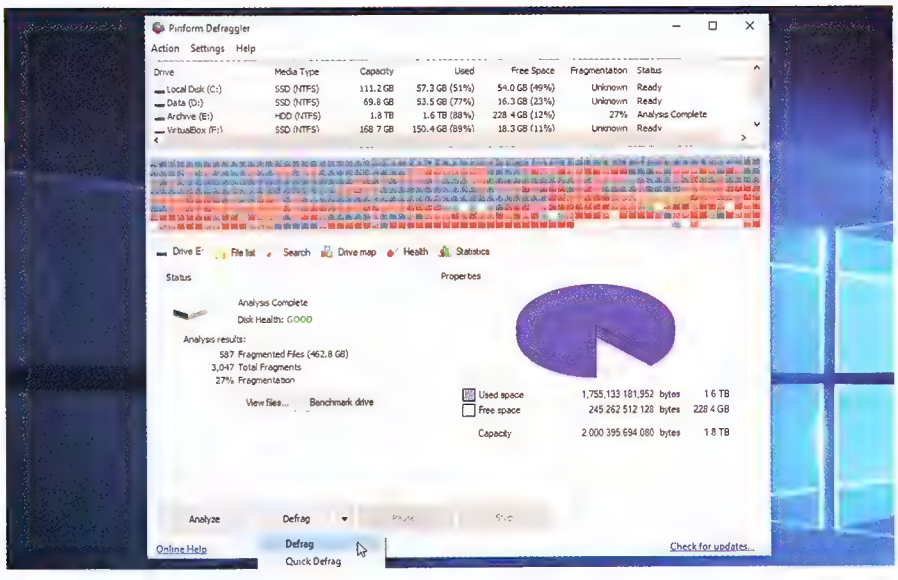
Easy Service Optimizer

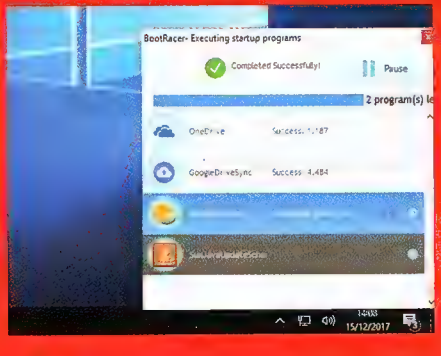
Services are special low-level programs that run in the background performing numerous functions. Each one uses its share of system resources and — armed with the right know-how — you can selectively disable them to free up memory and processor time. But why do it by hand when Easy Service Optimizer (**www.sordum.org/8637**) can do the hard work for you?

The program provides three presets: Safe, Tweaked and Extreme. For most people, Safe is best — it's a 'no-risk' option and you can easily revert to Default if things stop working as they should. Advanced users can go further, and the app enables you to manually tweak individual Services, too.

Defraggler

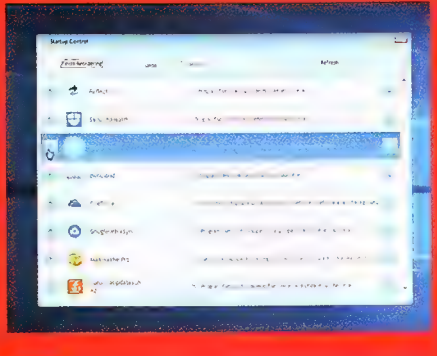
If you're still running Windows off a traditional platter-based hard drive, then keeping it defragged is a must. Windows' own Disk Defragmenter does a good enough job, particularly in Windows 10, but if you want to squeeze even more performance out of your drive, then Defraggler (**www.piriform.com**) is the tool to turn to. Not only can you opt to move large files to the end of the drive to help speed up performance, Defraggler enables you to defrag individual files and folders, too — perfect for quickly defragging a single file without tying up your PC for hours. Defraggler also offers an Optimise option for SSDs, which manually wipes space marked for deletion to boost drive performance.





3 STAGGERED LOADING

Furthermore, BootRacer also loads programs in sequence, one after the other — again to balance the demands on your PC. Click the three-line 'hamburger' button to reveal a list of all the programs that are loading, along with their respective start-up times.



4 MONITOR AND MANAGE APPS

Click 'Startup Control' from the main program to manage start-up programs. You can disable or delete them from here, and rearrange their running order — for example, to get fast-loading programs launched first.

JetBoost

JetBoost (**www.bluesprig.com/jetboost.html**) is a tool that quickly shuts down unnecessary services and programs on a temporary basis only. For example, if you play demanding games or encode HD video, JetBoost can deliver a speed boost for the duration, then restore everything for normal operation after — all via its one-click button. Also handy for silencing intrusive apps and notifications while you work.

Overclock your PC

Push your PC's components to their limits and deliver noticeable speed improvements with these hardware-tuning apps.

While there's no substitute for hardware upgrades to deliver the ultimate performance fillip, the fact remains it's likely that various components in your PC aren't being pushed to their absolute limits. By default, many components are configured in a conservative fashion, but armed with the right tools, you can start squeezing them that little bit further.

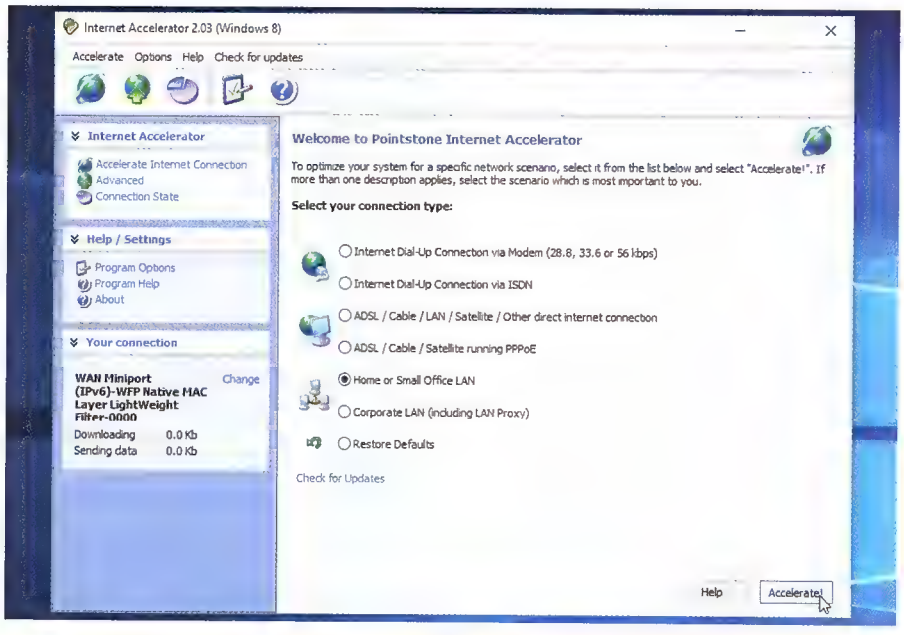
It's worth noting that overclocking – the process for speeding up your processor, RAM and graphics – will ultimately shorten the lifespan of these components, particularly if their core temperature rises. Thankfully, our recommended tools have built-in fail-safes and monitoring mechanisms so you can check that your tweaks aren't going to bring your PC to its knees. You'll also find out how to speed up other hardware areas, too – this time without introducing undue stress. Expect to deliver minor speed bumps to your solid-state drives (SSDs) and internet connection – also make sure you update your drivers to ensure the latest, fastest ones are in place.

Internet Accelerator 2

This free tool, which you can download from **www.pointstone.com/products/InternetAccelerator**, will work best on older machines running Windows 7 or earlier. It's designed to make it easy to tweak various Windows settings relating to your network connection, which can have a positive effect on various Internet-related activities.

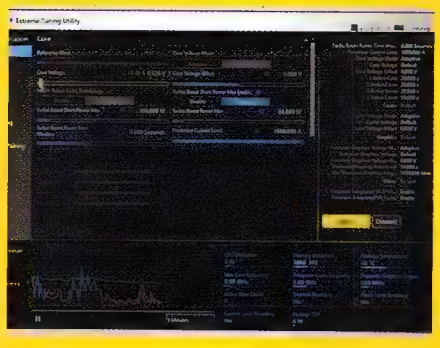
Internet Accelerator 2 won't physically increase the speed of your connection, but it will optimise your settings to make full use of the available bandwidth. It ensures your downloads, web browsing and so on are going as fast as they're able to.

To use it, select your setup type (home or small office LAN for most), then click 'Accelerate!' to see if you can speed things up.


Internet Accelerator 2.03 (Windows 8)
Accelerate Options Help Check for updates
Internet Accelerator
Accelerate Internet Connection
Advanced
Connection State
Help / Settings
Program Options
Program Help
About
Your connection
WAN Miniport (IPv6)-WFP Native MAC Layer LightWeight Filter-0000
Change
Downloading 0.0 Kb
Sending data 0.0 Kb
Welcome to Pointstone Internet Accelerator
To optimize your system for a specific network scenario, select it from the list below and select "Accelerate!". If more than one description applies, select the scenario which is most important to you.
Select your connection type:
Internet Dial-Up Connection via Modem (28.8, 33.6 or 56 kbps)
Internet Dial-Up Connection via ISDN
ADSL / Cable / LAN / Satellite / Other direct internet connection
ADSL / Cable / Satellite running PPPoE
Home or Small Office LAN
Corporate LAN (including LAN Proxy)
Restore Defaults
Check for Updates
Help
Accelerate!

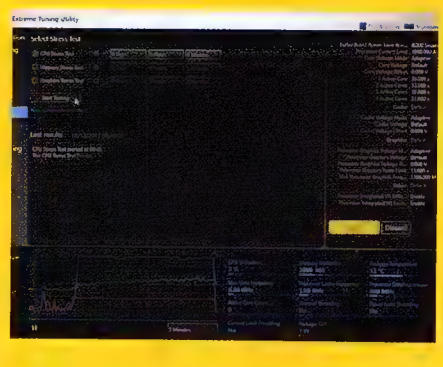
Overclock your PC

One way you can speed things up is by overclocking your processor so both it and your RAM run faster than they were designed to. There are dangers with this approach — overheating can shorten your components' lives — but official tools help to minimise the danger. AMD users should install AMD Overdrive (**www.amd.com/overdrive**); Intel users should download and install the Extreme Tuning Utility (**bit.ly/extrtunutil**).



1 OVERCLOCKING MADE EASY

Your overclocking options with Intel's utility vary according to the processor you have — some will be incredibly limited, others will offer more scope. If supported, the utility will also enable you to overclock the onboard graphics.



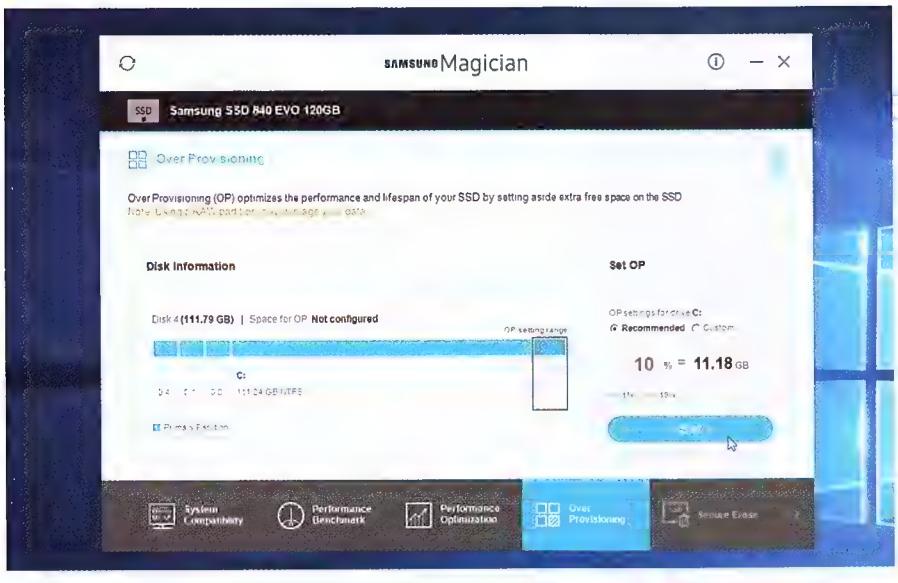
2 TEST YOUR OVERCLOCK

After tweaking your settings (visit **bit.ly/pcgoclock** for a detailed guide courtesy of PC Gamer), select Stress Test to perform a five-minute stress test across processor, memory and/or graphics depending on what you overclock.

MSI Afterburner

Overclocking your graphics card won't turn it into the latest model, but it can improve performance to make barely playable games run that bit more smoothly. If your PC comes with an AMD or Nvidia graphics chip, then MSI Afterburner (**www.msi.com/page/afterburner**) has your back.

It works by enabling you to tweak your chip's clock frequency and voltage while also giving you control over any onboard fans to help to try and minimise the temperature increase. Better still, there are real-time monitors to show you the effects of your overclock too. Remember — you risk damaging your graphics card by overclocking, so use with care (if at all).


SAMSUNG Magician
Samsung SSD 840 EVO 120GB
Over Provisioning
Over Provisioning (OP) optimizes the performance and lifespan of your SSD by setting aside extra free space on the SSD
Disk Information
Set OP
Disk 4 (111.79 GB) | Space for OP: Not configured
Recommended
10 % = 11.18 GB
System Compatibility
Performance Benchmark
Performance Optimization
Over Provisioning
Secure Erase

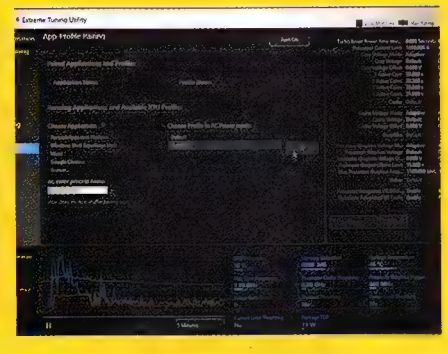
Solid-state drive (SSD) utilities

Is your SSD drive running to its maximum? Make sure to visit your drive manufacturer to download and install any software tools. These alert you to health issues, provide firmware updates, and may offer settings to tweak performance. For example, Samsung Magician (**bit.ly/2CUTUt7**) offers a Rapid Mode switch as well as Over Provisioning, which reserves free space on your SSD to further aid performance and lengthen its lifespan.

Similar tools can be found for OCZ (**bit.ly/2DnDgU4**), SanDisk (**bit.ly/2CT9Fk3**) and Crucial (**bit.ly/2CQDlym**) among others.

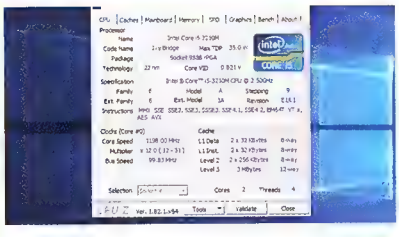
3 BENCHMARK IT

Select 'Benchmarking' to run a quick series of benchmarks to see the effects of your overclocking — benchmark before you start, and perform three benchmarks at a time, taking an average to give you a more accurate result.



4 APP-PROFILE PAIRING

Click 'Save' under Advanced Tuning to create a profile of your overclocked settings. Pair this profile with a specific app under App-Profile Pairing, so your PC is only overclocked when needed — for example, when playing games or HD video editing.



Motherboard tools

If you self-built your PC, or know its motherboard make and model (find it with CPU-Z at **www.cpuid.com**), visit the manufacturer's website where you may find alternative tools for tuning or overclocking your system. Examples include A-Tuning (ASRock), AI Suite 3 (ASUS) and OC Genie (MSI). You'll also find the latest drivers here too, some of which may also help to improve your PC's performance.

Reinstall tools

Ensure your next Windows reinstall goes without a hitch with the help of these essential tools and utilities,

When you next come to reinstall Windows, it pays to take precautions before you begin in the form of various backups – File History is essential for your personal data, but what about your program settings and how about a fail-safe backup in the event of a botched reinstall or forgotten file?

The reinstall process is also a good excuse to make changes to the way you organise data on your PC's main internal and external drives, while you'll also want to make sure that you have the latest versions of the Windows installation files to save you a lengthy post-install update process.

All these potential problems are covered by our favourite reinstall tools. You'll find the best drive backup tool in the business rubs shoulders with our favourite free partition editor and the Windows Media Creation Tool, which ensures you have the latest version of Windows 8.1 or 10.

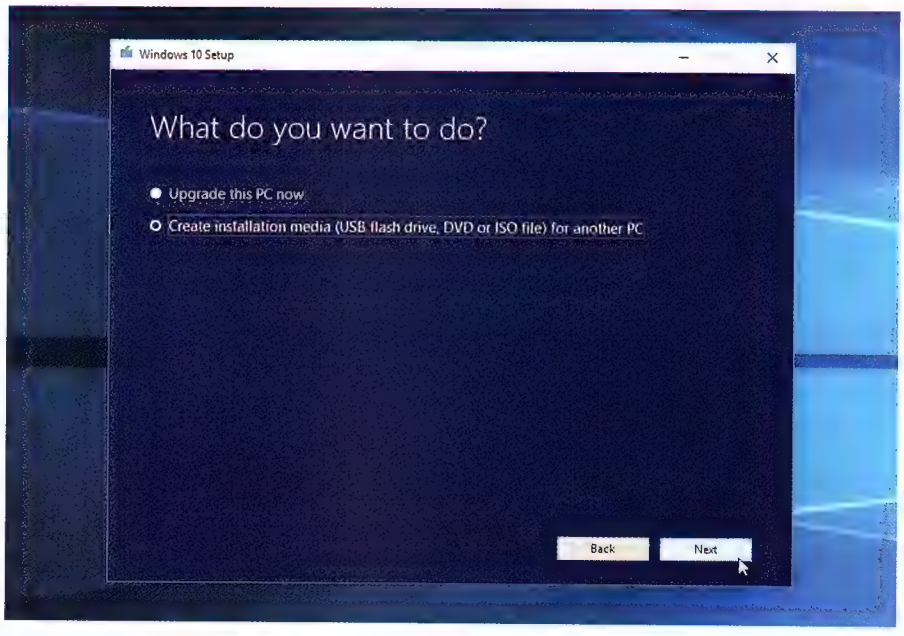
Throw in a couple of other handy applications and your next Windows reinstall just got a whole lot simpler (never mind safer).

Windows Media Creation Tool

The days of relying on an increasingly out-of-date installation disc are long gone. Simply download the Windows Media Creation Tool for Windows 8.1 (**www.microsoft.com/software-download/windows8**) or Windows 10 (**www.microsoft.com/software-download/windows10**) and it will walk you through the process of creating your reinstall media, either on DVD or a USB flash drive.

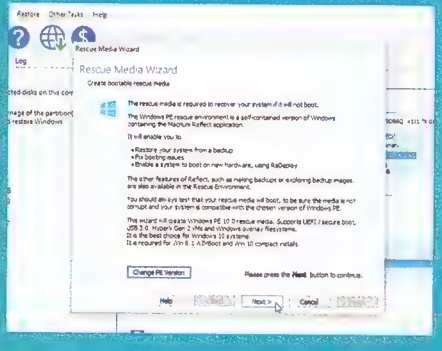
Better still, the Windows Media Creation Tool will also download the latest installation files first — which means if you reinstall Windows 10, for example, you'll get it with the Fall Creators Update already applied.

Always create fresh media prior to reinstalling Windows to ensure you have the latest version.

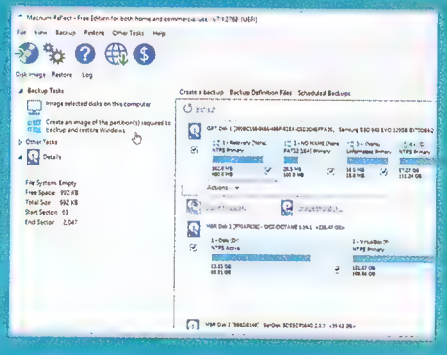

Windows 10 Setup
What do you want to do?
Upgrade this PC now
Create installation media (USB flash drive, DVD or ISO file) for another PC
Back
Next

Take a backup with Macrium Reflect Free

Reinstalling Windows from scratch is a one-way process. Once you've formatted the drive and reinstalled Windows everything you once had is gone. What happens if you forget a key file or setting, or the reinstall process goes wrong and you want to roll things back? Don't worry, Macrium Reflect Free (**www.macrium.com/reflectfree.aspx**) is just the tool for you — here's how you can use it to protect yourself and your PC files.



1 SORT RESCUE MEDIA
Launch Macrium Reflect Free and choose 'Other Tasks > Create Rescue Media' to create a bootable DVD or USB flash drive you can use to recover your Windows installation should something go catastrophically wrong with your PC.

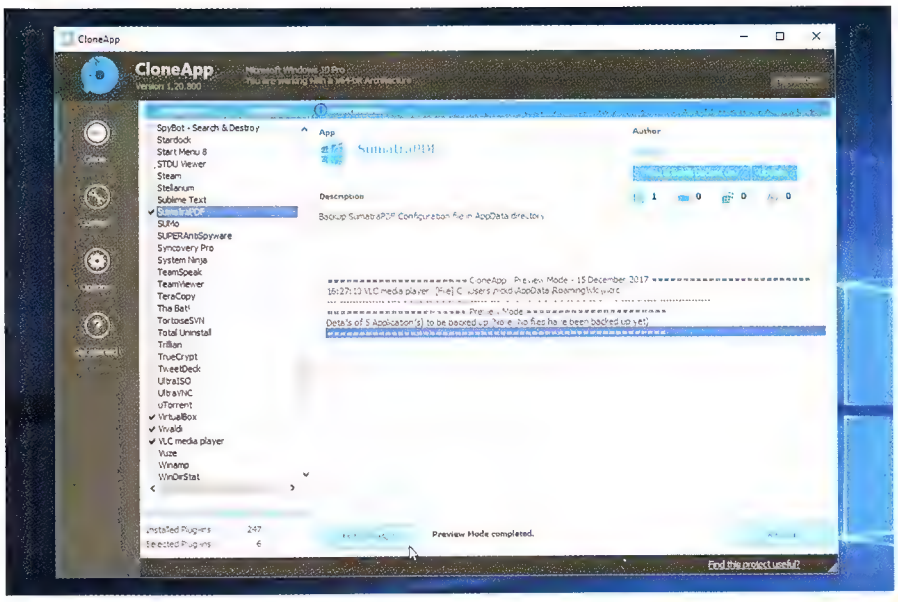


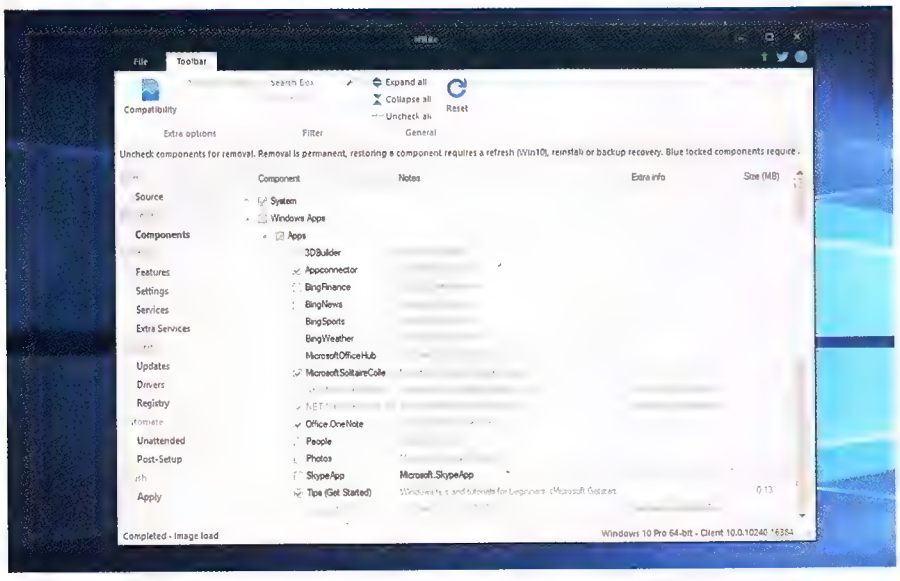
2 BACK UP PARTITIONS
Once done, click the 'Create an image of the partition(s) required to backup and restore Windows' button – Macrium will automatically select your Windows partition along with any boot partitions required to boot your PC.

CloneApp

One of the most time-consuming tasks after reinstalling Windows is restoring program settings. CloneApp (**www.mirinsoft.com**) allows you to selectively back up key directories and Registry settings where apps store their preferences. Nearly 250 program and Windows settings are plugged into the program — just locate your app, tick the box and it'll back everything up, but you can also add your own custom files and Registry entries too.

Once Windows and your apps have been reinstalled, just launch CloneApp and click Restore to put everything back again. To selectively restore program settings, open the CloneApp\Backup directory and remove any settings you want to exclude before running CloneApp.

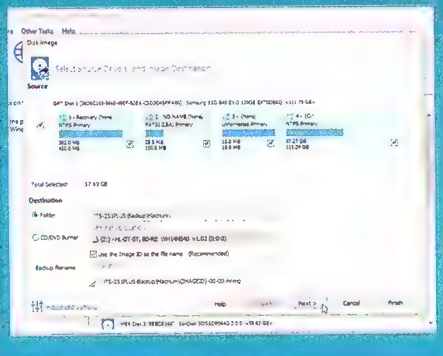


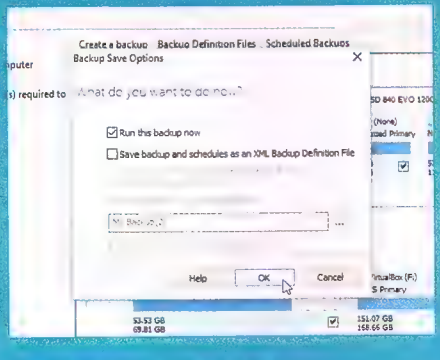


NTLite

Advanced users may feel frustrated at constantly having to tweak Windows after installation. NTLite makes it possible to build customised Windows 7, 8.1 or 10 installation media that not only has all the latest updates included (a boon for Windows 7 users), but which is tailored to your needs: you can integrate specific driver packages, remove unwanted Windows components (with built-in safety mechanisms to protect you from inadvertently removing stuff you might need) and perform various tweaks.

Certain features are restricted in the free edition — purchase the full version for €40 ($65) and you can even perform these tweaks to your current Windows installation, for example.



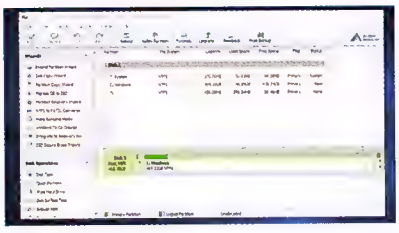


3 CHOOSE A LOCATION

Click the ellipsis (...) next to Folder under Destination to select a suitable folder on your backup drive. Click 'Advanced Options' and tick 'Verify image...' under Auto Verify Image, before clicking OK followed by Next.

4 CHECK AND BACKUP

Ignore the Schedules screen — this is a one-time fail-safe backup prior to reinstallation. Click 'Next', review the backup settings and click Finish. Untick 'Save backup...' and click OK for Macrium to back up and verify the image.



Partition Assistant

AOMEI's Partition Assistant Standard (**www.aomeitech.com/aomei-partition-assistant.html**) enables you to divide up your PC's storage drive into two or more partitions. Why partition your drive? Doing so enables you to separate your personal data — documents, photos and so on — from Windows and your apps. When you next come to reinstall Windows, your files are already safely stored on another drive.

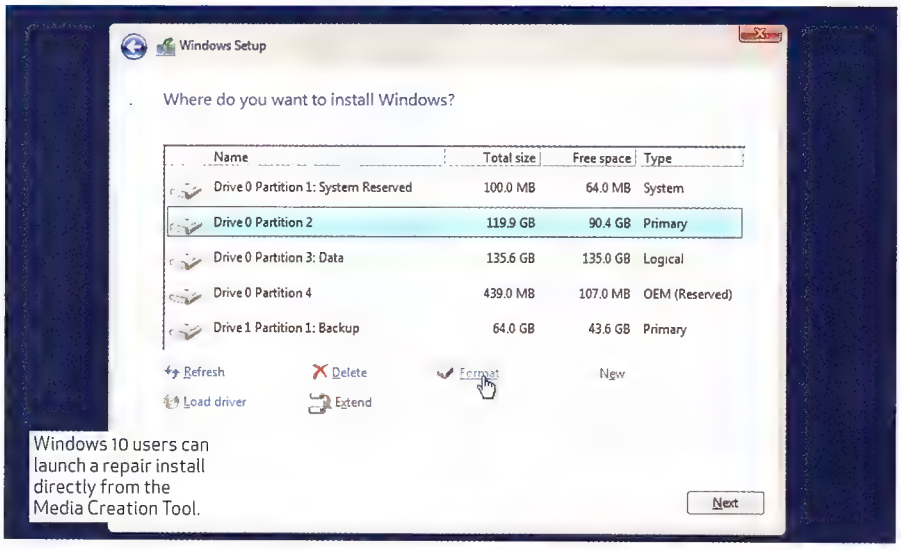
A full, destructive reinstall

If you're looking to wipe the slate clean, or need to recover from major issues, the nuclear option is always the best one.

Reinstalling Windows from scratch – namely, wiping your system drive completely clean to install a brand, spanking new (and fresh) version of Windows onto it – is the ultimate choice for anyone looking to revive a slow-running PC or resolve a major, non-hardware issue, such as those caused by malware or a clogged up computer. In this final section, we'll step you through the entire process.

Ideally, you should have a recent and full backup of your PC, created using either File History or the Windows Backup and Restore tool before you begin, that way you'll lose the minimum of content. A full reinstall really is destructive – nothing left on your C: drive will exist once you've finished. You should ensure you have the latest installation media for your target version of Windows – see our section on the Windows Media Creation Tool (back over the page) for tips on how to do this. This will ensure a cleaner, more up-to-date installation, thus saving you time bringing it fully up to date once the installation has completed.

It's also worth sourcing networking and graphics drivers now rather than relying on Windows to provide them for you – in most cases, they should be built in, but not always. Consult your PC or motherboard manufacturer's website for these, or visit your Wi-Fi adaptor or graphics card manufacturer's site – download them to your backup drive.

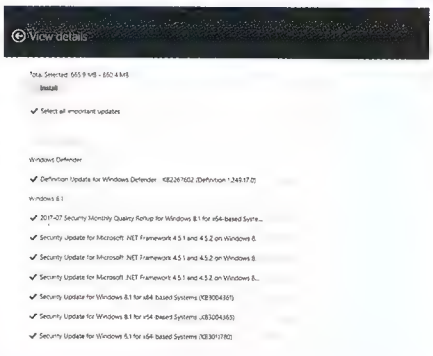


Windows 10 users can launch a repair install directly from the Media Creation Tool.

Other things to consider: uninstall any products that require activation now – this should deactivate the licences and enable you to use them with your new install without any issues. Also, be sure to have product keys and program installers to hand.

START THE REINSTALL PROCESS

A full destructive reinstall should always be started by booting from your installation media, be it a DVD or USB flash drive. The actual reinstall



Windows 7 and 8.1 users will find a large number of updates waiting to be installed after reinstalling.

Restore programs, settings and data

Once Windows has been reinstalled, open Windows Update to bring Windows fully up to date – don't be surprised if there are hundreds of updates still to apply in the case of Windows 7 and 8.1. Once it's fully up to date, consider reinstalling Macrium Reflect Free (back over the page) and taking your first drive image – a vanilla backup you can restore in future instead of reinstalling the OS.

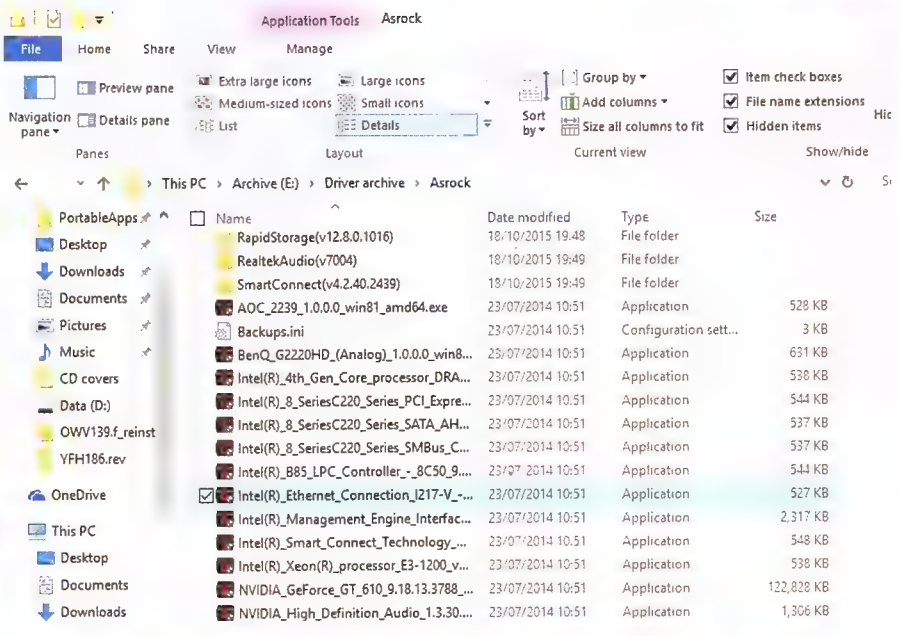
If you followed the advice on the previous page, you should now be able to reinstall your core apps using CloneApp from your PC's data drive. If you click the Restore button, every program setting you backed up will be restored – if there are any backup settings you don't want to restore, select Options to locate the backup folder, then open it and move any program folders you want to ignore out of the folder temporarily before clicking the Restore button. Once that's done, take your second Macrium Reflect Free backup.

Finally, open File History or the Windows Backup and Restore tool and take steps to restore any data you backed up, then make sure that either tool is configured to carry on backing up all your precious files going forward.

process doesn't differ much across Windows 7, 8.1 or 10. You'll be asked to verify your language, location and keyboard are set correctly, then it's a case of clicking 'Install Now'. If prompted, enter your product key or click Skip if you're running Windows 10 on a PC you upgraded during the free period. When asked what type of installation you wish to perform, choose the Custom option.

Next comes potentially the trickiest part of the process. A list of drives and partitions will appear — you need to select the one Windows is currently installed on. By default, it should be detected and selected, but verify it's correct before clicking Format (click the advanced Drive Options button if it's not visible). Click 'OK', then once formatted, verify the drive is still selected and click Next.

That's the technical stuff pretty much done. You'll see a checklist of tasks to be performed — just sit back and wait. One thing to note: when Windows reboots, you may see the 'press any key' prompt again to boot from CD or DVD. Don't press anything if that happens, just let the installer continue.



> "Next comes potentially the trickiest part of the process. A list of drives and partitions will appear — you need to select the one Windows is currently installed on."

SET UP POST-INSTALL

The post-setup prompt begins with Windows 7 users being prompted for their product key, then it's a case of setting up a user account and you're off and running. Windows 8.1 users will get an Express Settings prompt — be sure to click the option to customise these and go through them carefully.

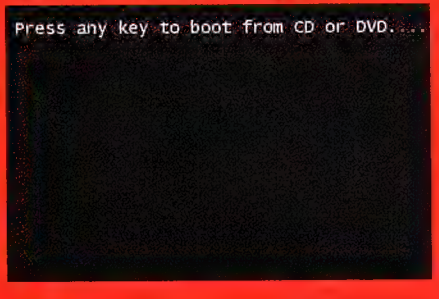
Post-Creators Update, Windows 10 no longer gives you an Express Settings option. For now, confirm your location and keyboard, set up your network if required and choose 'personal use' when prompted. You can either sign in with your Microsoft account or click 'Offline account > Maybe later' if you plan to stick with the old-style Windows 7 local user account.

If you opt for the Microsoft account option, now is a good time to set up a PIN to speed up future logins (note: the PIN is tied specifically to this PC, and you can always bypass it using your regular account password should you forget it at any point).

You'll then be asked to set up Cortana — this is where Windows 10's notorious privacy settings come into play, so review all of the options carefully, flicking the slider to Off for any you don't need or use.

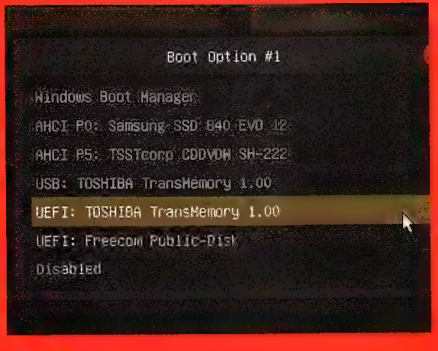
Windows will now configure itself based on each of your choices and you'll see a series of messages appear on-screen. Eventually, when all is ready, you'll find yourself back at the familiar Windows desktop screen. ■

Start the install process



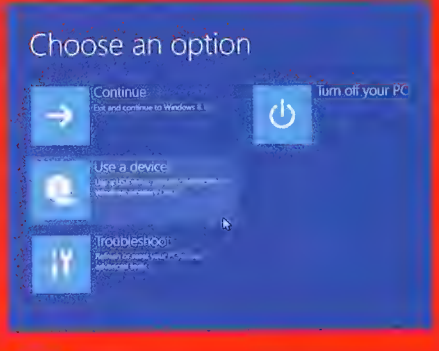
1 REBOOT FOR MEDIA

If you're running Windows 7, or have Fast Boot disabled, insert your boot media and start your PC. Look for a 'Press any key to boot from CD or DVD' option — even if you have booted from a USB flash drive. Press any key on your keyboard and you should find that the Windows install process starts.



2 TWEAK BOOT OPTIONS

If you boot back into Windows, restart your PC again, but this time press a key, such as F11, when prompted to open a boot menu. Once done, select your boot media — choosing UEFI if that option appears — to boot; otherwise, enter setup so that you can change the boot device order.



3 WINDOWS 8.1/10

If Fast Boot is enabled on your computer, open Settings in Windows and then navigate to 'Update & recovery > Recovery', then click 'Restart now' under 'Advanced start-up'. When the boot options appear, choose 'Use a device' to select the USB flash drive or DVD you created from the list that appears.

MEMORY MATTERS

A fresh look at the state of DDR4 in 2018.

"Understanding how memory works, and what you should be spending your cash on, as far as memory is concerned, is now more pivotal than ever."

We often describe the PC as having its own ecosystem, almost as though it's some form of living entity, and the symbiotic relationship between each component is almost a perfect example of Aristotle's (oft misparaphrased) saying "The whole is more than the sum of its parts." Admittedly, the Greek philosophical genius was likely referring to metaphysics and ideologies, rather than the modern-day abacus, yet in our eyes, the saying is more apt here than anywhere else.

After all, you only have to take one core component out of the typical system's arsenal, and you render the machine incapable of function. Whether that's a processor, memory or motherboard, the crux of the matter is that this holy trinity of hardware combines to create a perfect amalgamation of machine-based interfacing – yet, isolated, the components themselves fold for less value.

Not only does this metaphor exist for PC itself, but it also extends to the PC marketplace. With the prices of both memory and GPUs skyrocketing, inevitably those generational spikes in performance we've been seeing across the computing industry over the last 10 years are going to evaporate – because the price of memory has nearly tripled, new platform adopters are forced to go for lower-spec parts.

This has a knock-on effect across game development, video production, CGI... Hell, even us tech journos are going to feel the bite. Whether it's mining, supply issues or a bit of both, the ecosystem is suffering, and there's not a lot we can do to change that, but understanding how memory works, and what you should be spending your cash on, as far as memory is concerned, is now more pivotal than ever. So it's time for us to bust out the magnifying glass and shine a light on the volatile world of memory.

The obsession with speed

Memory speed is one of the most convoluted specifications around, and is often misrepresented. Way back when, in the early days of SDRAM development, the megahertz measurement was the correct way of advertising the associated speeds of memory. In short, every single solid-state component in your machine operates at a specific frequency, or Hz – whether it's your processor, GPU, memory or even SSD, each one operates on a cycle. Like the ticking of a clock, each tick represents a single hertz or cycle (the opening and closing of a transistor gate, in this case). A speed of 1Hz, for example, is one cycle per second; 2Hz is two per second; a MHz is 1,000,000 cycles per second; you get the picture.

The problem is, when DDR (or double data rate) RAM came on the scene, it changed how data transfers were registered. Instead of only actuating once on the rising of each clock cycle, it could now also process an additional operation on the fall of that same clock cycle, effectively doubling the rate at which the DIMM could process data. The figure for accurate measurement of data transfer requests then shifted from MHz to MT/s to adjust for this change, despite the fact that memory still operated at the same frequency. However, marketing apparently didn't get that memo, because many companies, in a bid to tout it as the next big thing, ignored the MT/s figure, instead referring to it as MHz, while modern-day memory quoted at 2,400MHz, for instance, only operates at half that frequency.

Timings and latency

The next part of the holy trinity of memory specifications revolves around timings and latency. There's a ton of them, but the most important one you need to keep in mind is the CAS latency. Referring to the Column Address Strobe, this figure indicates just how many clock cycles it's going to take for the memory module to access a particular memory location, either to store or retrieve a bit of data held there, ready for processing by the CPU.

That said, this figure on its own doesn't give you all the information you need. It's only when you combine it with the memory transfer rate we mentioned above that you get a better picture of just how fast your memory modules are. So how do we get a figure that makes any sort of logical sense to us consumers? Well, there's a handy formula that converts CAS latency and MT/s into a real-world latency: Latency = (2,000/Y) x Z, where Y is your RAM's speed in MT/s, and Z is your CAS latency.

So, as an example, if we take a 2,666MT/s memory kit, operating with a CAS latency of 15, we get a real-world result of 11.25ns. This tells us exactly the total time it takes for that memory module to access, store, or request a bit of data from a location on the module.

This is where overclocking memory typically comes unstuck. Generally, the higher the frequency, the higher the CAS latency, and as such, real-world performance gains are often slim, unless the rise of that CAS latency is slowed as well. When it comes to the "best" performing memory, what you're looking for is a kit that has a high frequency, a low CAS latency, and the necessary capacity (see opposite) to do what you want to do.

RAM LATENCIES

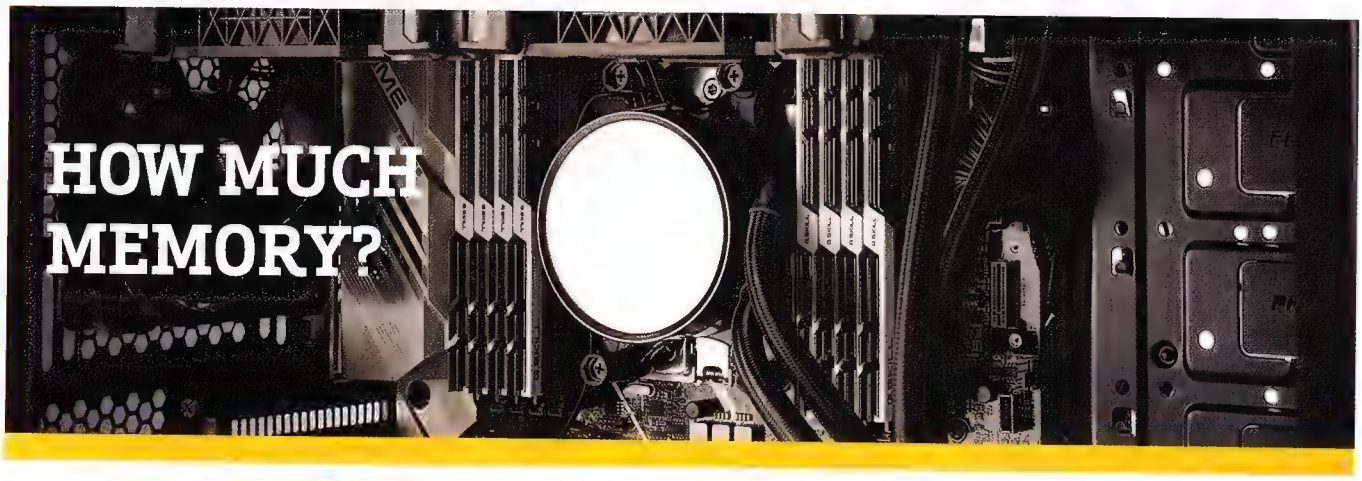
TECHNOLOGY	MEMORY CHIP CAPACITY	TRANSFER RATE (MT/S)	CAS LATENCY (NS)	REAL LATENCY (NS)
DDR2	500MB	400	5	25
DDR2	500MB	800	5	12.5
DDR3	1GB	800	9	22.5
DDR3	1GB	2,400	11	9.17
DDR4	2GB	2,133	15	14.06
DDR4	2GB	4,500	19	8.44
DDR5*	4GB	4,266	23	10.78
DDR5*	4GB	6,400	27	8.44

Capacity for capacity

To understand how memory capacity is calculated, we have to look at how the chips themselves are designed. This starts with JEDEC, an association of over 300 different companies that focus on solid-state technology. Its task is to ensure that universal standards are used across the registered companies when it comes to solid-state tech, with a particular emphasis on DRAM, solid-state drives, and interfaces (NVMe and AHCI, for instance). What this does is ensure that the consumer won't have to pick between four different connection standards for DDR4, for example, and everything is consistent across multiple manufacturers – aka no proprietary BS. As far as memory is concerned, JEDEC lists the criteria that, say, DDR4 needs to adhere to – for instance, the number of pin outs, the dimensions of the chips, the maximum power draw, and more.

That spec is then handed over to the manufacturers, such as Samsung, SK-Hynix, Toshiba, and Micron, to produce memory chips to their own specifications that fit into JEDEC's criteria. Typically, the differences lie within the size of the manufacturing process used (which additionally affects power draw). These chips are then bought by aftermarket partners, such as Corsair, HyperX, G.Skill and so on, to be assembled with their own PCBs, heatsinks, and aftermarket features (RGB LEDs, anyone?), while, of course, still adhering to JEDEC's original outline.

Currently, due to limitations in transistor size, DDR4 chips are limited to just 1GB each, although a theoretical 2GB per chip is well within the JEDEC specification. In the consumer market, most DIMMs can only support up to a maximum of 16 memory chips per stick, meaning a maximum capacity of 16GB per DIMM is possible. You can find larger sticks in the enterprise market, typically featuring up to 32GB per stick, but these are designed for server use rather than the consumer market, and are priced into the thousands.



HOW MUCH MEMORY?

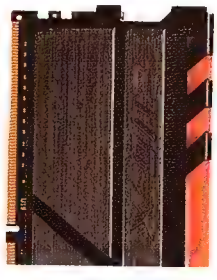
So in this world of hyperinflated memory prices, just how much DDR4 is enough for what you want to do? It's tricky. A year or so ago, we would have happily sat here and recommended 64GB of DDR4 for any video editor or content creator out there. But, to be honest, given the ludicrous price increases (more on that later), that's just not a practical or good use of your money in this day and age.

4GB

If all you're building is a home theater PC or a machine for low-end office work (we're not talking 4,000-cell Excel files here), then arguably a single 4GB stick of low-spec DDR4 should be perfect for the job. Couple that with a low-end Pentium part, and you're all set. For those keen miners out there, this is also the ideal spec for a cryptocurrency mining rig, because mining is typically not as memory-intensive as other more mainstream applications (but you should pass on the Pentium if you're planning to mine CPU-intensive currencies).

8GB

If entry-level gaming is your jam, 8GB (2 x 4GB) is the absolute minimum we'd recommend at this point in time. Ironically, the lower the amount of VRAM on your GPU, the more likely the system is to cache overly large texture files on to the actual RAM itself (here's looking at you *COD: WWII*) – dual-channel here helps with those massive transfers.



16GB

For mid-range to high-end gaming, you absolutely need that 16GB of DDR4. Annoyingly, more and more games are starting to use more and more memory. Yearly releases and poorly optimised titles are putting more strain on system memory, with even *Star Citizen* recently announcing a minimum spec of 16GB of RAM purely to run the Alpha. 16GB is also a nice middleweight RAM capacity for any task you want to throw at your rig. Whether that's extensive office work, Photoshop, entry-level videography, you name it, it's the right spec for you.

32GB

For anyone who makes a living from 3D modeling and content creation, 32GB is the way to go for the time being. Although this will more than likely still set you back $400 or more, it's the absolutely perfect amount for applications such as After Effects, 4K Premiere Pro and more.

32GB-plus

For now, unless you can somehow get it aggressively subsidised, anything beyond 32GB just isn't worth it, at least not until prices drop below that $700 mark once more.

Price hikes

IF you haven't built or upgraded a machine recently, you might not realise that memory pricing has gone crazy over the last 12–16 months. Memory kits have seen their prices at least double during this period, with some almost trebling. That means that while, a year or two ago, the amount of memory you put in a system could be decided on a whim, it now has to be a carefully thought-out plan if you want to keep any machine up to date and capable of the workloads intended. But why have prices increased so much? And what are the chances of them coming back down to more reasonable levels?

The biggest problem for DRAM is that producing flash is far more lucrative. The reason for this is primarily down to one thing: smartphones. The specifications for these tiny powerhouses are constantly on the rise, so the amount of storage and RAM they ship with has risen sharply recently. As they are premium products, the amount of money being charged for them has gone through the roof.

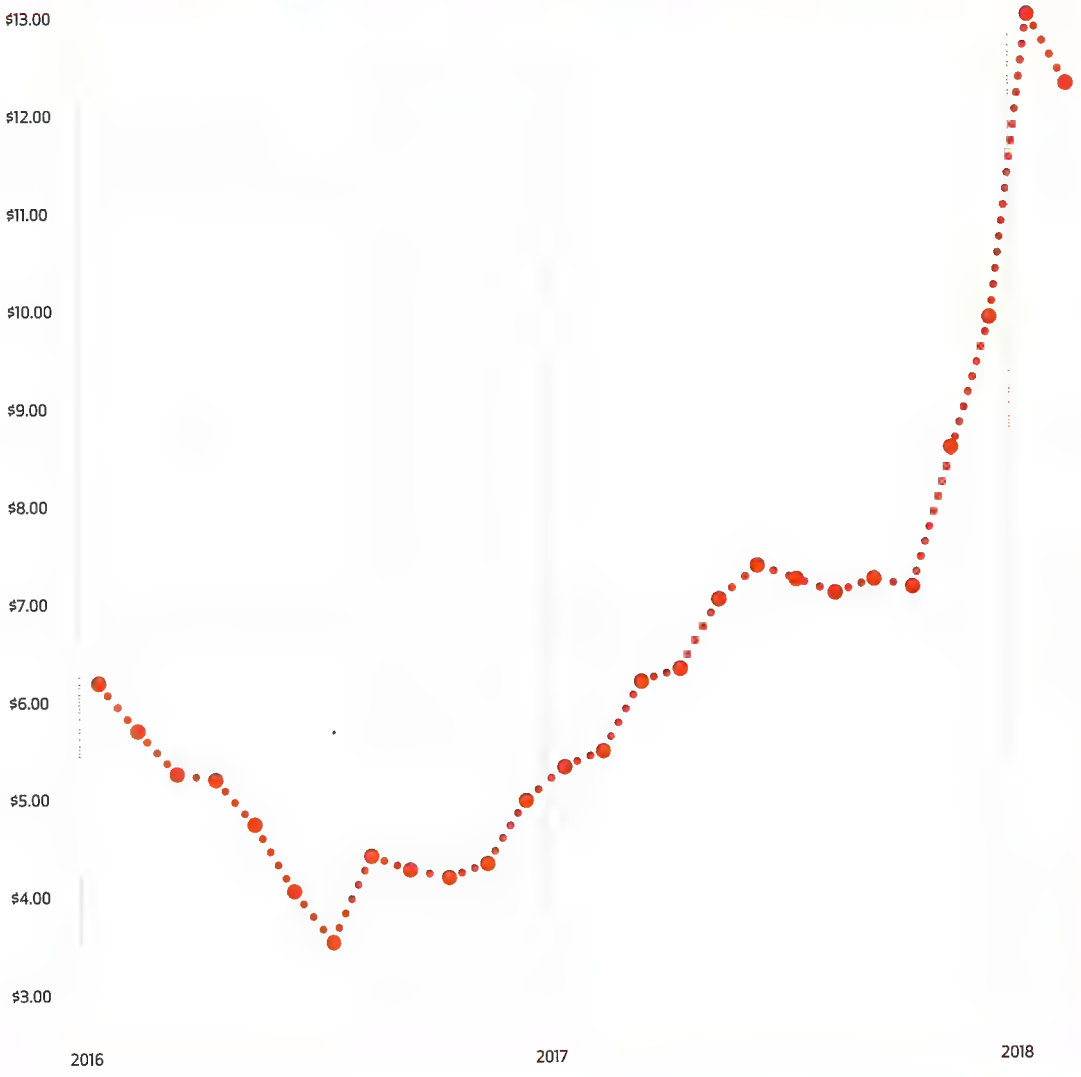
You might be sitting there thinking that high-speed desktop DDR4 RAM has nothing to do with NAND flash, and in a sense you'd be right, but the plants that manufacturer NAND are also the ones responsible for our beloved DDR4. So because it's financially more advantageous to switch over to NAND, that's exactly what has happened, and will probably keep happening for a while yet. It might be important to us, but desktop RAM is relatively low on the pecking order as far as manufacturers are concerned.

There is another reason for the current high prices, though, and that's down to market demand. We had some decent platform releases last year, which meant there has been a slew of people in the market looking to buy more RAM. Yes, it's Ryzen's fault. Well, not really, but the new platform has certainly not helped the situation.

If you're looking to upgrade a system with more RAM, it could be worth hanging tight for a little longer, because the memory market has a history of righting itself once serious money is involved. If you're looking to build a new system, your options aren't as obvious, because the simple fact of the matter is that RAM is going to cost you. Buy wisely. And be ready to pounce when pricing does return to more reasonable levels.

Memory pricing gone haywire

We've collated the average memory prices over the last two years from the builds that have graced the rear of the magazine. This is an average of memory pricing across all three rigs, on a per gigabyte basis (which helps mitigate the fact that our high end builds tend to use 4 x 8GB DIMMs, while budget builds uses a pair of 4GB sticks). How we pick memory for these builds is also affected by pricing — if RAM prices are high, we pick lower-frequency DIMMs. So there is some margin of error, but the general trend shown in this graph is hard to ignore.



Channel bandwidth

What is channel bandwidth and how does it affect memory? Think of it as the maximum amount of data that can be transferred at any one time between your system and the memory installed. It's calculated by using MT/s, the width of the memory bus, and the number of memory channels your system supports. So for a typical Ryzen 7 1800X system, featuring 16GB (2 x 8GB) of 3,200MT/s DDR4, it's something like this.

3,200,000,000 (3,200MT/s) x 64 (64-bit bus) x 2 (dual-channel) = 409.6 billion bits per second, or 51,200MB/s, or 51.2GB/s.

That's the absolute maximum amount of data the system could transfer between the memory and the processor at any given time, before bottlenecking. If you were to use a 4 x 4GB kit on your dual-channel board, bandwidth wouldn't increase, because the processor can still only read and write from two memory channels at a time (thus the dual-channel spec), despite the fact that you have four DIMMs installed. On the flip side, installing just one DIMM cuts that figure in half.

It's worth noting that, for most applications, dual-channel memory kits provide you with more than enough bandwidth for everything you want to do on your desktop. However, for applications that manipulate massive data sets, textures, and more, an increase in channel support can eliminate potential bottlenecks, because more powerful processors become more capable at manipulating larger data sets. 4K, 5K and 8K video editing in After Effects, for instance, benefits greatly from having access to both a larger memory capacity and increased memory bandwidth, thanks to quad-channel support.

The future

JEDEC is poised to announce the next-gen memory standard (DDR5) later this year, and has confirmed a few details for us: "DDR5 will offer improved performance, with greater power efficiency compared to previous generation DRAM technologies. As planned, DDR5 will provide double the bandwidth, and density over DDR4, along with delivering improved channel efficiency."

That's exciting, if only for the fact that power consumption should drop — DDR3 sat at 1.5V and DDR4 at 1.2V, so it's likely we'll see DDR5 at 1.0V or lower. The doubling of density means we'll likely see mobos double in max capacity, too, with mainstream platforms maxing out at 128GB, and high-end desktops hitting a 256GB limit. Expect initial MT/s figures to hit around 4,133MT/s, with latencies at 27ns if not more. However, it's unlikely to come into production until late 2019.

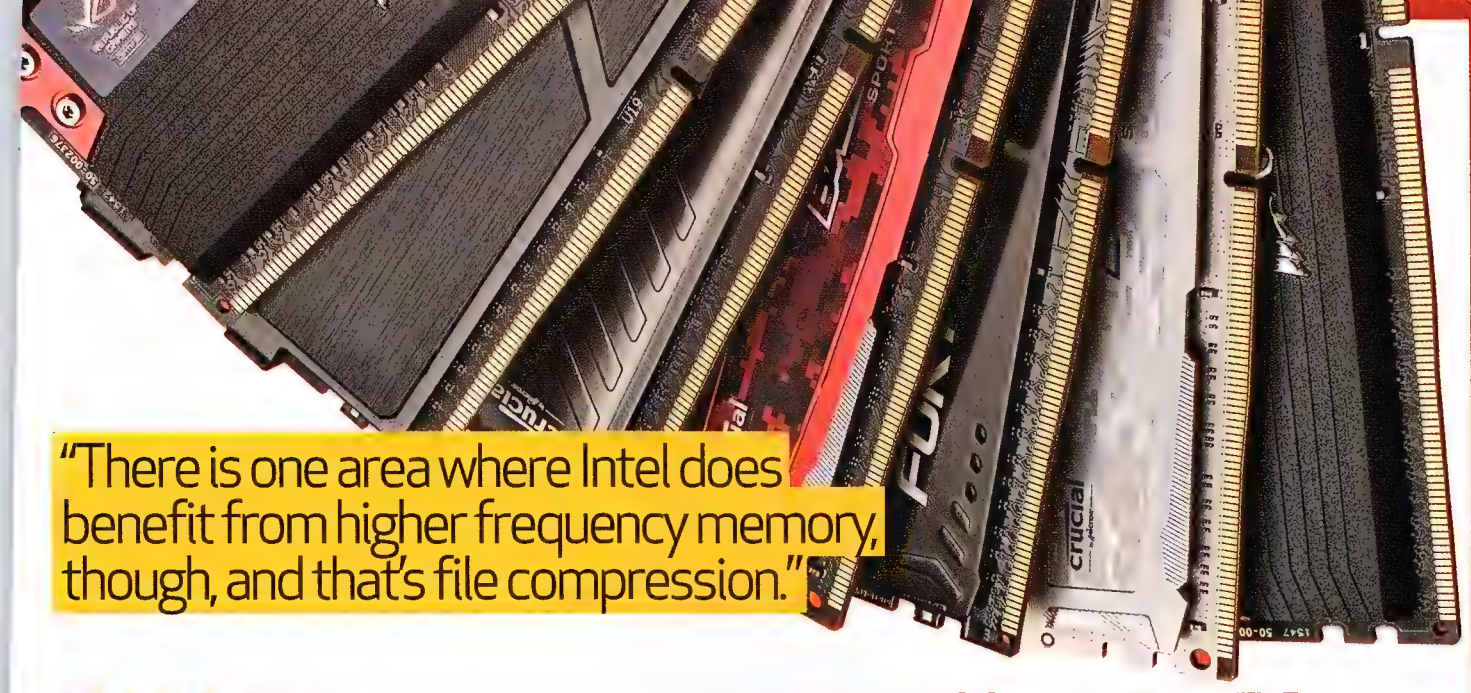
Standardisation

What exactly are JEDEC's standards? And why are they necessary? Well, the biggest reason they exist is to ensure consumers have a non-convoluted platform. They also ensure that motherboard manufacturers don't have to design four different types of motherboard, just because Corsair has its own connection standard, HyperX another, and G.Skill a slightly different variant. You get the picture. Think of it like USB, but for memory. The biggy is that all 300 members can pool their resources to accelerate technological development, without any one of them getting a competitive edge, and saving them time and money in the process. It's worth noting that JEDEC's standards are on the fairly conservative side of things when it comes to memory frequency (after all, they're designed to work with everything from desktops to servers and supercomputers), and DDR5 has yet to be clarified in its entirety just yet, but you can see from the table below just what standards each manufacturer has to adhere to.

> "You can see from the table below just what standards each manufacturer has to adhere to."

JEDEC STANDARD DDR4 MODULE

STANDARD NAME	DATA RATE (MT/S)	MODULE NAME	CAS LATENCY (NS)	REAL LATENCY (NS)
DDR4-1600J	1,600	PC4-1600	10	12.5
DDR4-1600K	1,600	PC4-1600	11	13.75
DDR4-1600L	1,600	PC4-1600	12	15
DDR4-1866L	1,866	PC4-1866	12	12.86
DDR4-1866M	1,866	PC4-1866	13	13.93
DDR4-1866N	1,866	PC4-1866	14	15.01
DDR4-2133N	2,133	PC4-2133	14	13.13
DDR4-2133P	2,133	PC4-2133	15	14.06
DDR4-2133R	2,133	PC4-2133	16	15
DDR4-2400P	2,400	PC4-2400	15	12.5
DDR4-2400R	2,400	PC4-2400	16	13.33
DDR4-2400U	2, 400	PC4-2400	18	15



"There is one area where Intel does benefit from higher frequency memory, though, and that's file compression."

Intel: How memory speeds affect Big Blue

When it comes to memory, over the years, Intel's architecture has benefitted very little from increased frequencies. Certainly, the current mainstream platform sees little to no performance increases when fixed up with higher frequency memory with lower latencies. When it comes to mainstream applications, gaming and even video editing to some degree, if you're sitting pretty on Z77 and above, you'll likely have enough bandwidth to do anything you want, without having to shell out for higher frequency kits for the additional bandwidth. There is one area where Intel does benefit from higher frequency memory, though, and that's file compression. If you're exporting and sending compressed files on a day-to-day basis, memory speed does help significantly. That said, it's a fairly niche scenario. All we can suggest, then, is that the best thing to do when speccing out a new system is to find a reasonable frequency (2,400 or 2,666MT/s) memory kit at a capacity that suits your needs.

We've recommended a few kits as examples (see over the page), so pick a kit with similar specs for as little money as you can find.

BENCHMARKS

8GB DDR4	CINEBENCH R15 SINGLE/MULTI (INDEX)	AIDA 64 MEMORY READ (MB/S)	AIDA 64 LATENCY (NS)	TOTAL WAR WARHAMMER II (LOW AND AVG FPS)	MIDDLE EARTH SHADOW OF WAR (LOW AND AVG FPS)	10GB WINRAR ARCHIVE TIME (SECONDS)
CORE I7-8700K @ 2,400MT/S	204/1,521	35,933	65	38/43	22/51	245
CORE I7-8700K @ 2,666MT/S	205/1,522	39,418	53.1	39/43	28/53	232
CORE I7-8700K @ 3,000MT/S	205/1,527	44,130	51.2	39/43	25/53	223
CORE I7-8700K @ 3,200MT/S	204/1,526	46,802	47.3	31/43	34/51	215

BENCHMARKS

12GB DDR4	CINEBENCH R15 SINGLE/MULTI (INDEX)	AIDA 64 MEMORY READ (MB/S)	AIDA 64 LATENCY (NS)	TOTAL WAR WARHAMMER II (LOW AND AVG FPS)	MIDDLE EARTH SHADOW OF WAR (LOW AND AVG FPS)	10GB WINRAR ARCHIVE TIME (SECONDS)
CORE I7-8700K @ 2,400MT/S	204/1,515	35,282	57.5	38/43	34/51	245
CORE I7-8700K @ 2,666MT/S	205/1,532	38,936	53.4	33/43	24/51	231
CORE I7-8700K @ 3,000MT/S	205/1,544	43,662	49.3	33/43	35/52	225
CORE I7-8700K @ 3,200MT/S	204/1,541	46,153	47.1	38/43	24/52	216

BENCHMARKS

32GB DDR4	CINEBENCH R15 SINGLE/MULTI (INDEX)	AIDA 64 MEMORY READ (MB/S)	AIDA 64 LATENCY (NS)	TOTAL WAR WARHAMMER II (LOW AND AVG FPS)	MIDDLE EARTH SHADOW OF WAR (LOW AND AVG FPS)	10GB WINRAR ARCHIVE TIME (SECONDS)
CORE I9-7900X @ 2,400MT/S	195/2,175	62,432	84.4	33/43	29/52	197
CORE I9-7900X @ 2,666MT/S	194/2,167	70,065	77.3	36/42	32/51	192
CORE I9-7900X @ 3,000MT/S	191/2,197	77,599	73.8	31/43	24/51	185
CORE I9-7900X @ 3,200MT/S	194/2,177	83,063	70.3	34/43	26/52	182

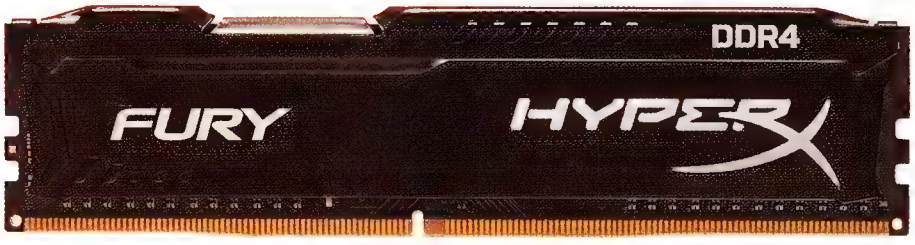
OUR APC LABS TEST PC CONSISTS OF AN ASUS Z370 MAXIMUS X HERO FOR THE CORE I7, AND AN ASUS X299 PRIME DELUXE MOTHERBOARD FOR THE CORE I9. ALL MEMORY TESTS WERE PERFORMED WITH EITHER 8GB OR 16GB CORSAIR DOMINATOR PLATINUM DIMMS, WITH A CAS LATENCY OF 16.

APC recommended specs for Intel

Right then, what do we recommend, memory-wise, for your latest immersion into the Intel platform? Well, given the vast swathe of different setups and use cases out there, we've categorised our selections into three rather generic specs: one for office work, one for gaming and one for creating grade-A quality content. It's worth noting that you don't have to stick with the brands we've highlighted – because prices are fluctuating about rather haphazardly at this point, you'll probably find brands jumping in and out of being the best value kit you can get. Stick with trusted brands, such as Corsair, Crucial, G.Skill and HyperX, though, and you'll be good.

OFFICE & HOME THEATRE

As we mentioned earlier, if all you're wanting to do is run office software and browse the web, a single stick of DDR4 4GB will do you just fine. Unfortunately, that means you'll be forking out about 50 whole smackeroonies for this 2,400MT/s kit (sadly, that's the state of affairs we're now faced with). Real-world latency is pretty attractive, though, coming in at 12.5ns at CAS 15 — not that it'll matter for these kind of applications.



HYPERX FURY 4GB (1 x 4GB) @ 2,400MT/S, CAS 15 $85–$95

GAMING

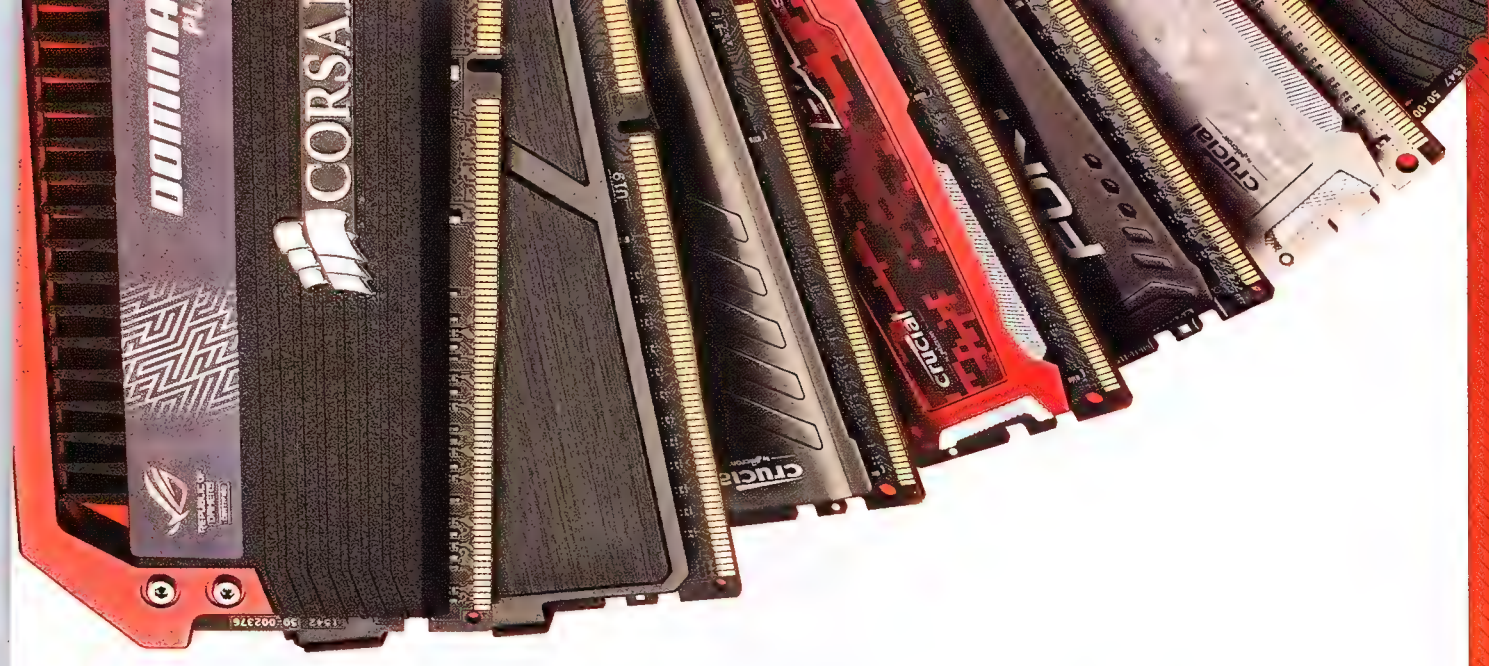
16GB is ideal for future-proofing yourself against the inevitable rise of HD texture packs and unoptimized AAA titles. Yes, devs should be working harder on coding, rather than the "Can it run Crysis?" crapfest of a mindset, but there's not a lot we can do to influence that. 2,400MT/s at 16GB is perfect under Intel's platform. Combine that with a CAS latency of 16, for around $170, and you've got a fast (13.34ns) future-proof kit.

CRUCIAL BALLISTIX SPORT LT 16GB (2 x 8GB) @ 2,400MT/S, CAS 16 $260–$280

WORKSTATION

Until memory prices change, 32GB is the go-to spec we recommend for anyone looking at the more expensive workstation-oriented stuff. There's some good value kits out there — Corsair's Vengeance LPX series, in particular, has long been a staple of our high-end test benches. Again, as Intel doesn't benefit much from the frequency side of things, 2,666MT/s is a sweet deal for any would-be video editor.

CORSAIR VENGEANCE LPX 32GB (4 x 8GB) @ 2,666MT/S, CAS 16 $580–$600



AMD: Memory mastery for Team Red

Ryzen is an oddity when it comes to memory. For the first time in eons, memory speed impacts processor performance. Simply going from 2,666MT/s to 3,200MT/s can equate to a performance increase of around 10% in rendering tasks. Combine that with an overclock on your Ryzen CPU, and you can net yourself almost 25% more grunt. Why is this? It's all down to how AMD has crafted its Infinity Fabric. This is the interface that connects all the core complexes in the processor together, enabling them to communicate with one another. The Infinity Fabric is directly controlled by the IMC (integrated memory controller), so the higher the speed of the memory, the faster the IMC operates, and the quicker the processor can transfer bits of data across each core complex. It's a smart solution, but it does mean that Ryzen is somewhat bound by its dependency on faster memory – not so good when the memory market is priced as high as it is today.

So, best bet? If you're heading toward Team Red's Ryzen platform, get the highest frequency memory you can, at a capacity that best suits you.

BENCHMARKS

8GB DDR4	CINEBENCH R15 SINGLE/MULTI (INDEX)	AIDA 64 MEMORY READ (MB/S)	AIDA 64 LATENCY (NS)	TOTAL WAR WARHAMMER II (LOW AND AVG FPS)	MIDDLE EARTH SHADOW OF WAR (LOW AND AVG FPS)	10GB WINRAR ARCHIVE TIME (SECONDS)
RYZEN 7 1800X @ 2,400MT/S	156/1,607	37,299	91.4	32/42	18/51	344
RYZEN 7 1800X @ 2,666MT/S	153/1,615	41,307	87.3	33/42	22/50	340
RYZEN 7 1800X @ 3,000MT/S	154/1,632	46,202	79.9	37/43	28/51	316
RYZEN 7 1800X @ 3,200MT/S	155/1,638	48,473	76.5	35/43	31/51	308

BENCHMARKS

12GB DDR4	CINEBENCH R15 SINGLE/MULTI (INDEX)	AIDA 64 MEMORY READ (MB/S)	AIDA 64 LATENCY (NS)	TOTAL WAR WARHAMMER II (LOW AND AVG FPS)	MIDDLE EARTH SHADOW OF WAR (LOW AND AVG FPS)	10GB WINRAR ARCHIVE TIME (SECONDS)
RYZEN 7 1800X @ 2,400MT/S	153/1,607	36,523	93.7	30/41	17/51	345
RYZEN 7 1800X @ 2,666MT/S	149/1,612	40,436	88.9	30/41	18/50	336
RYZEN 7 1800X @ 3,000MT/S	150/1,620	45,717	80.6	37/43	29/52	319
RYZEN 7 1800X @ 3,200MT/S	154/1,632	47,850	75.1	35/43	27/52	311

BENCHMARKS

32GB DDR4	CINEBENCH R15 SINGLE/MULTI (INDEX)	AIDA 64 MEMORY READ (MB/S)	AIDA 64 LATENCY (NS)	TOTAL WAR WARHAMMER II (LOW AND AVG FPS)	MIDDLE EARTH SHADOW OF WAR (LOW AND AVG FPS)	10GB WINRAR ARCHIVE TIME (SECONDS)
THREADRIPPER 1950X @ 2,400MT/S	141/2,891	56,524	113.7	38/43	24/55	532
THREADRIPPER 1950X @ 2,666MT/S	138/2,902	62,712	106.2	31/43	25/54	505
THREADRIPPER 1950X @ 3,000MT/S	140/2,939	71,961	97	39/43	24/53	472
THREADRIPPER 1950X @ 3,200MT/S	139/2,945	74,992	94.3	39/44	23/53	464

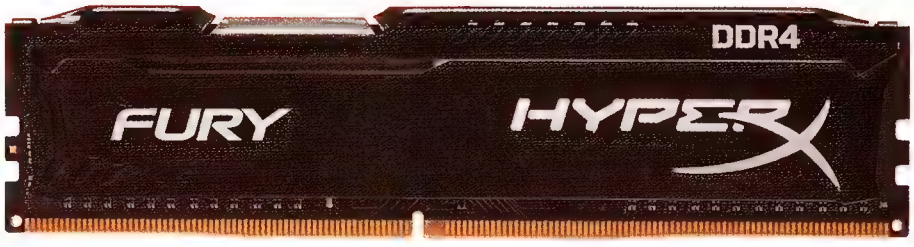
OUR APC LABS TEST PC CONSISTS OF AN ASUS X370 CROSSHAIR VI HERO FOR RYZEN, AND AN ASUS X399 ROG ZENITH EXTREME MOTHERBOARD FOR THREADRIPPER. ALL MEMORY TESTS WERE PERFORMED WITH EITHER 8GB OR 16GB CORSAIR DOMINATOR PLATINUM DIMMS, WITH A CAS LATENCY OF 16.

APC recommended specs for AMD

Now we've wrapped up exactly how AMD benefits from memory speed in particular (thanks, Infinity Fabric), it's time we got down to the nitty-gritty of recommending some kits and specs. As with the Intel recommendations, it's worth noting that you don't need to stick with the brands we've picked out below, because prices are fluctuating about rather haphazardly at this point. We've just tried to balance, price, spec and performance to come up with the perfect pairings for your AMD-based build.

OFFICE & HOME THEATRE

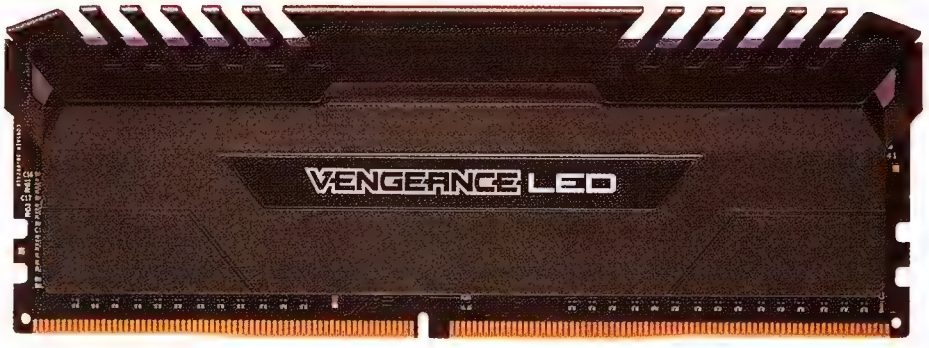
Let's assume you have an old GPU from an out-of-date system that you're going to be plugging into this build, because until the Zen APUs come out, you'll need a dedicated GPU to run a Ryzen HTPC or office system. A single stick of 4GB DDR4 at 2,666MT/s fits the bill perfectly. Ryzen has always been a bit fussy with memory, so make sure you go for a mainstream brand here, and stick with 2,666MT/s and above where you can.



HYPERX FURY 4GB (1 x 4GB) @ 2,666MT/S, CAS 16 $85–$100

GAMING

That price jump is painful, but we reckon it's worth it for this kit. For gaming, frame rates matter, and near-instantaneous communication between Ryzen's intricate core complexes certainly helps batter those low frame rates into submission, at the very least. With a super-low latency of 10ns, a 3,200MT/s kit with a CAS latency of 16 will set you back a good $300, but it's definitely the best way to game on Ryzen. Period.



CORSAIR VENGEANCE 16GB (2 x 8GB) @ 3,200MT/S, CAS 16 $300–$320

WORKSTATION

We've opted for more capacity here, but a slight drop in frequency in contrast with the gaming recommendation above. This is mostly centered around the notion that the gains from Threadripper's memory speed increase (from 3,000 to 3,200) weren't that impressive. That said, it's still a kick-ass kit, and the latency combo is perfect, if you can get a kit at a good price. G.Skill's Ripjaws V series is the best value we've seen so far.

CORSAIR VENGEANCE LPX 32GB (4 x 8GB) @ 3,000MT/S, CAS 15 $630–$720

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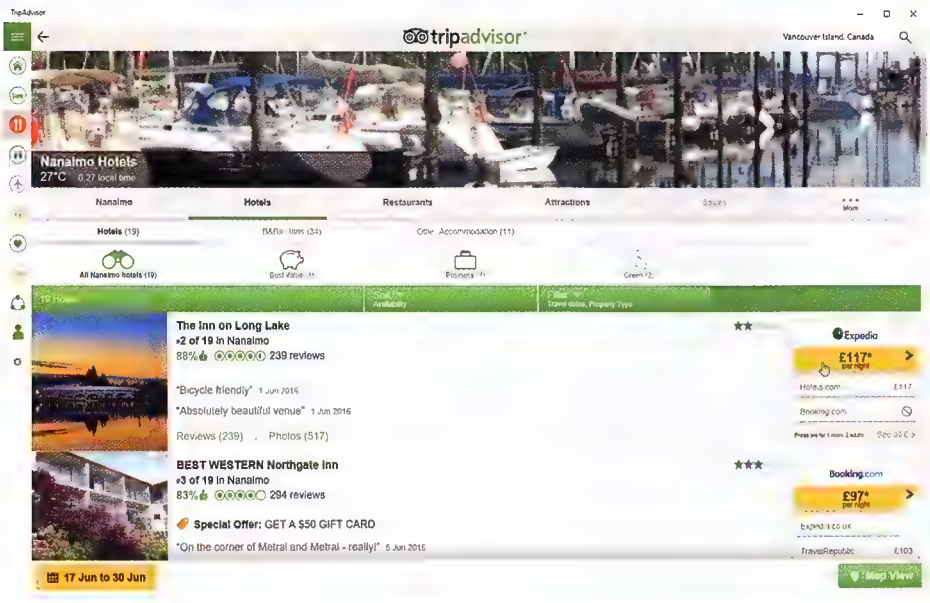
25 best Windows apps

Nick Peers shares our 25 best apps for Windows 10. Download them now and get more from your PC today!

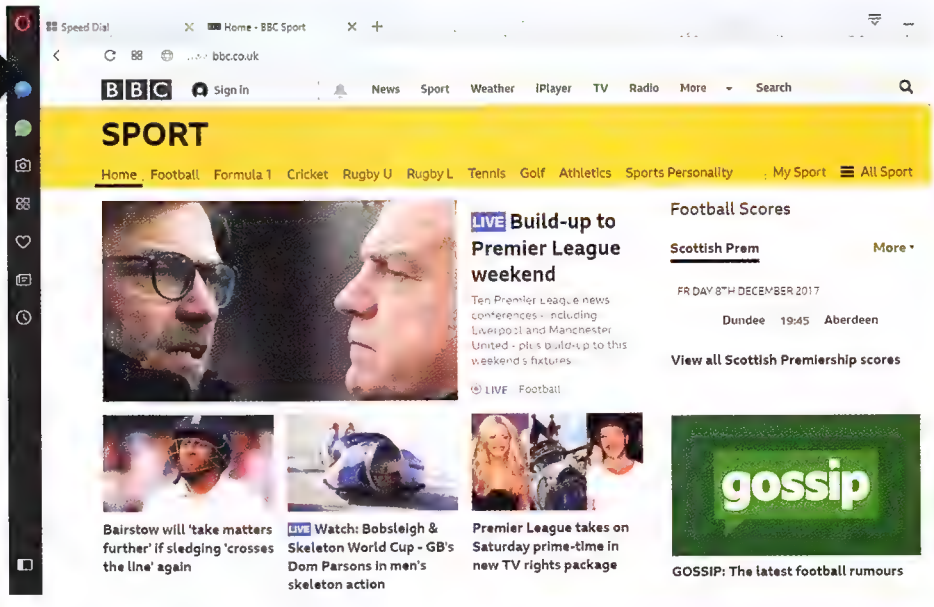


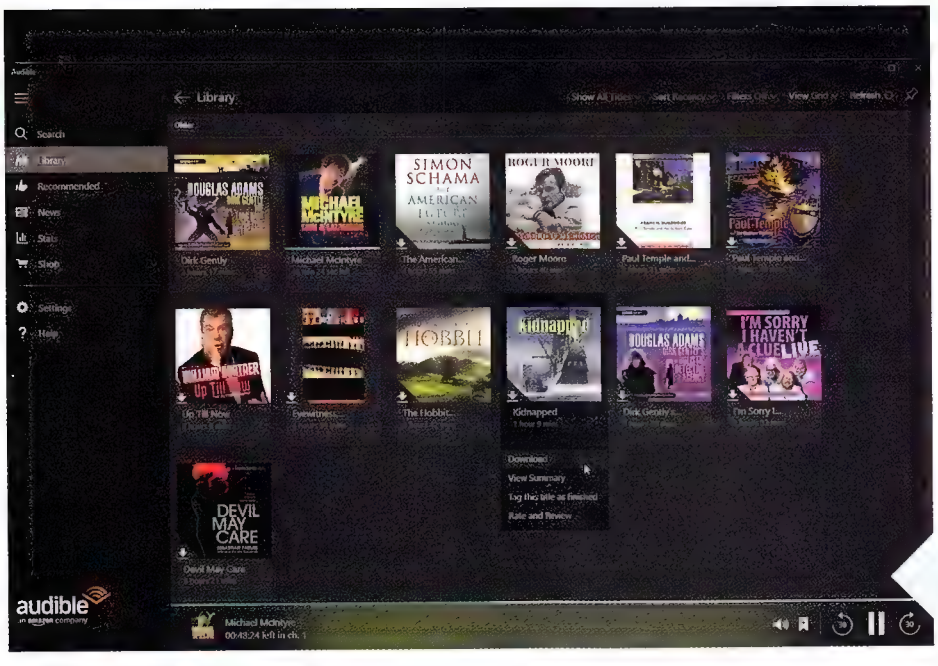
Plan your next trip

Whether you need help with travel, days out, hotels or things to do while on holiday, the **TripAdvisor** app (free, Microsoft Store) has you covered. Not only can you find what you're looking for, but you can book directly through the app too, comparing prices to get the best possible deal. Look out for the 'areas of interest' section, giving you ideas for your next break.

Faster, easier web browsing

All web browsers are pretty much the same, aren't they? Not really. **Opera (www.opera.com)** has made a striking bid for uniqueness with a sleek, simple interface and the ability to sync your settings between multiple devices. Also, recent updates have introduced native ad-blocking, VPN for secure browsing and power-saving for laptops and tablets.



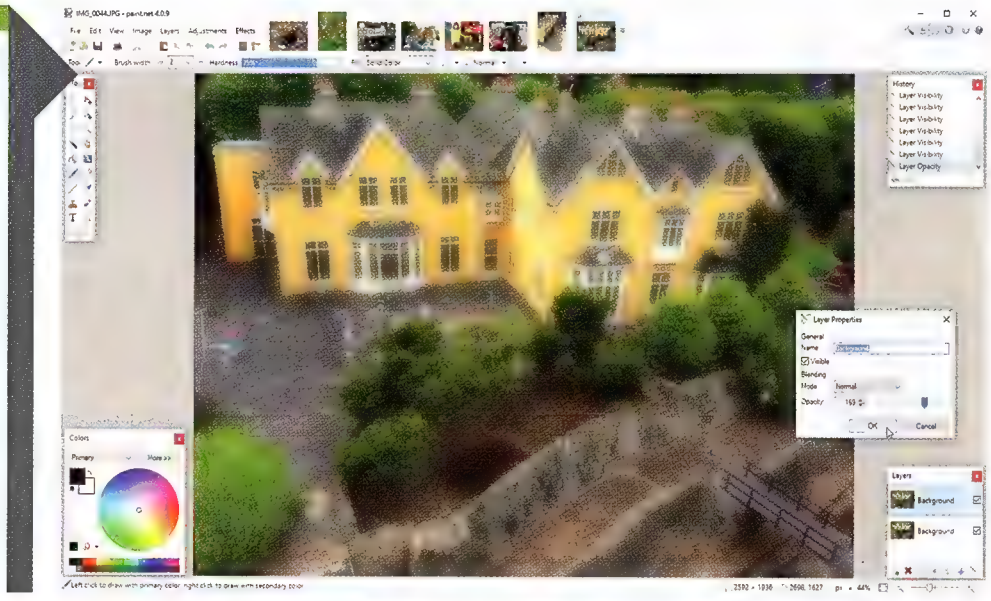


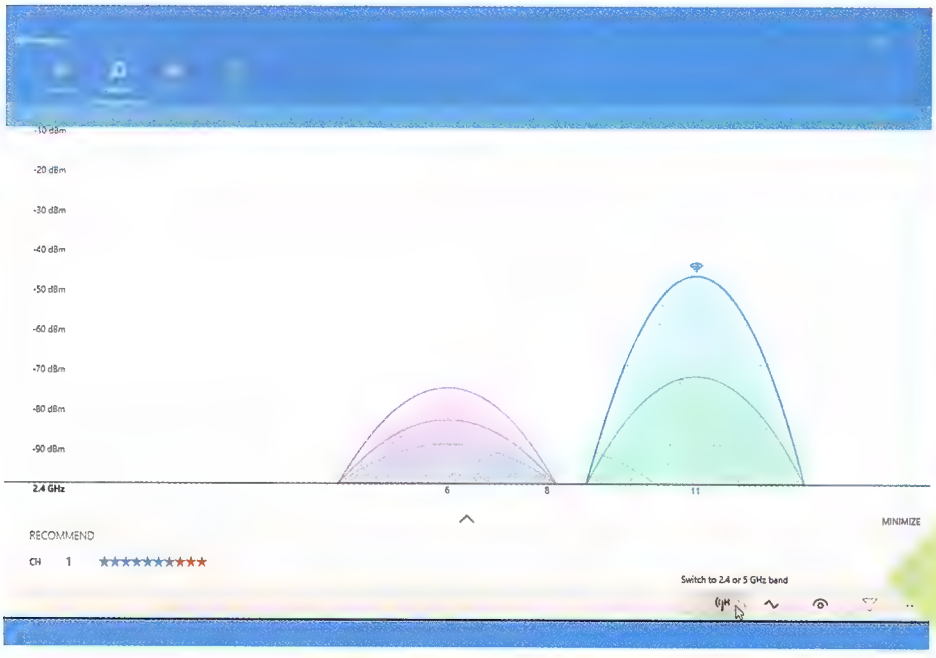
Listen to audiobooks

One of the best ways to kill long, tedious journeys — particularly if you're driving — is with an audiobook. And the go-to place for getting digital audiobooks is Amazon's **Audible**. Install the Audible app (free, Microsoft Store) on your PC and you can buy, manage and — crucially, of course — listen to your purchases on your computer too.

Image-editing for experts

If you want a complete set of professional-level editing tools without the cost, then **Paint.NET** (free, **www.getpaint.net**) is the best there is. Support for multiple layers, powerful filters and the ability to extend its capabilities further with a series of community-written plugins make Paint.NET an essential tool in anyone's creative toolkit.



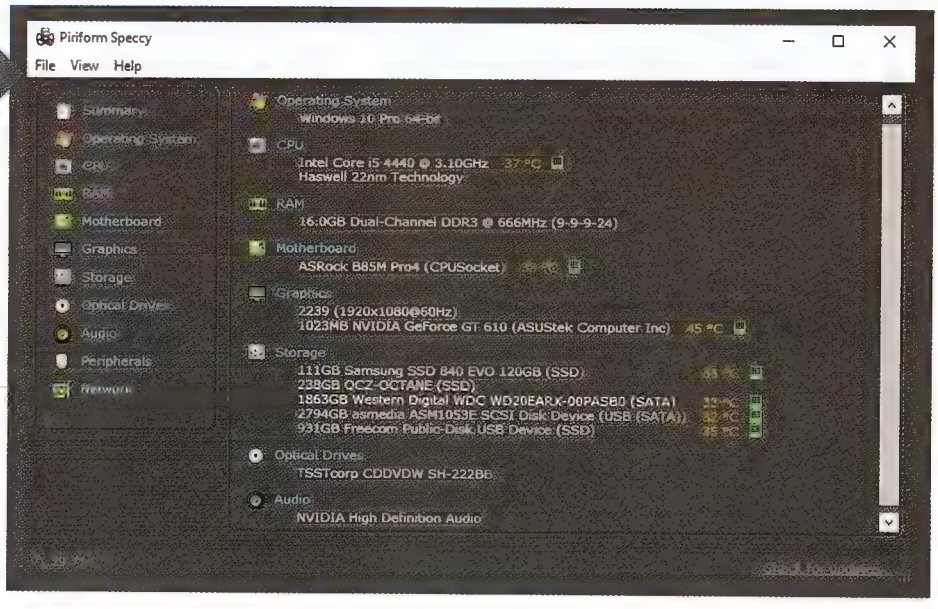


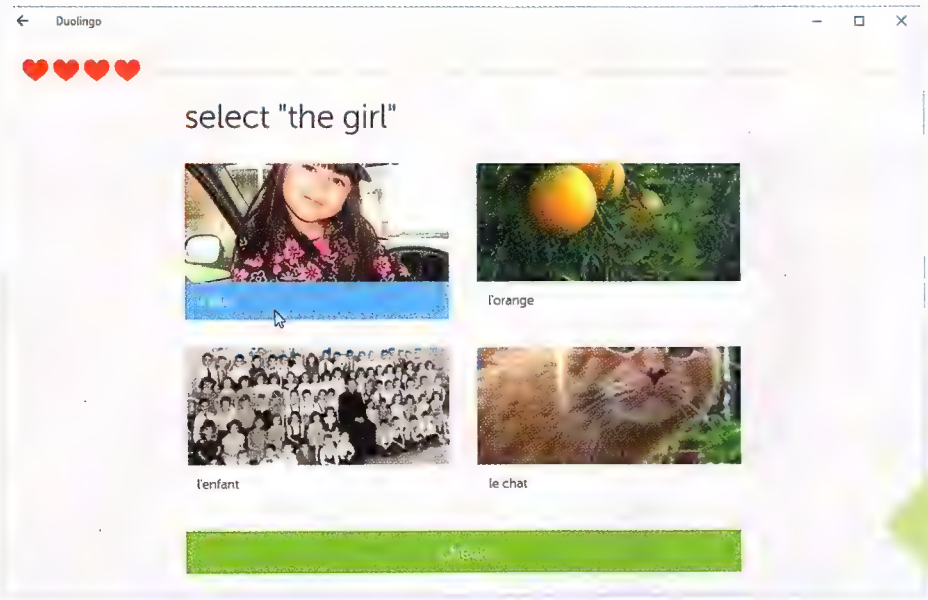
Improve your Wi-Fi signal

One of the biggest problems with wireless connections is the overlapping of networks, causing dropouts and performance issues. **Wi-Fi Analyzer** (free, Microsoft Store) provides you with a handy summary of your network, plus lets you compare it to other networks, suggesting the best channel to switch it to in order to minimise interference and boost performance.

Get useful system info

Want to find out more about the makeup of your PC? Need to keep an eye on the temperature of your computer while you're running intensive tasks? Install **Speccy** (free, **www.piriform.com**) and it'll reveal all kinds of useful detail, not just about the hardware in your system, but also Windows itself (including your product key).



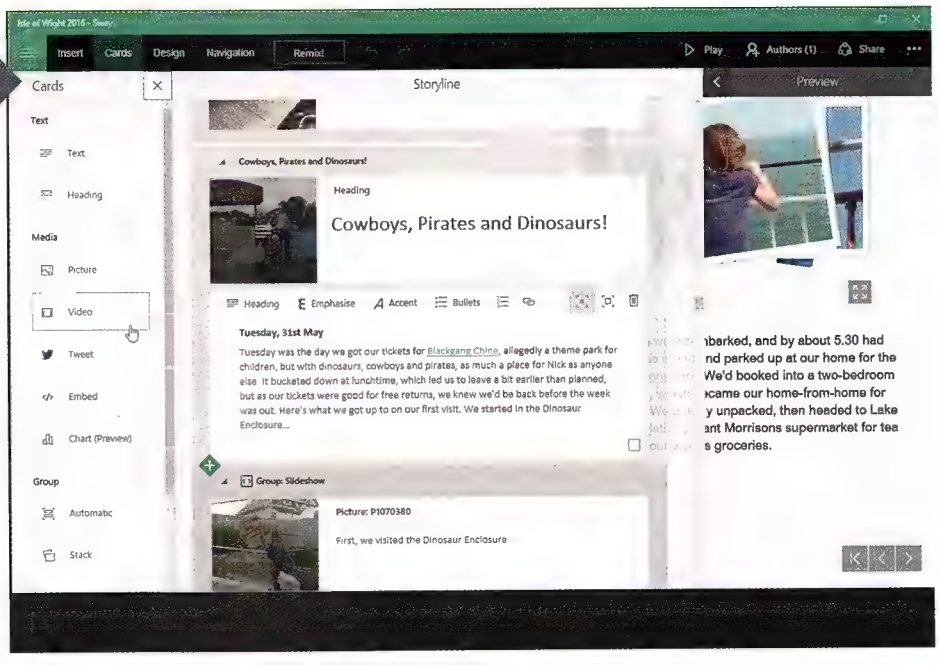


Learn new languages

Need to brush up on your linguistic skills, or want to learn a new language from scratch? **DuoLingo** (free, Microsoft Store) is the perfect, easy-to-follow tool that'll teach you up to 12 new European languages in a series of lessons divided into modules and tests. Visit **www.techradar.com/1314224** for a complete guide.

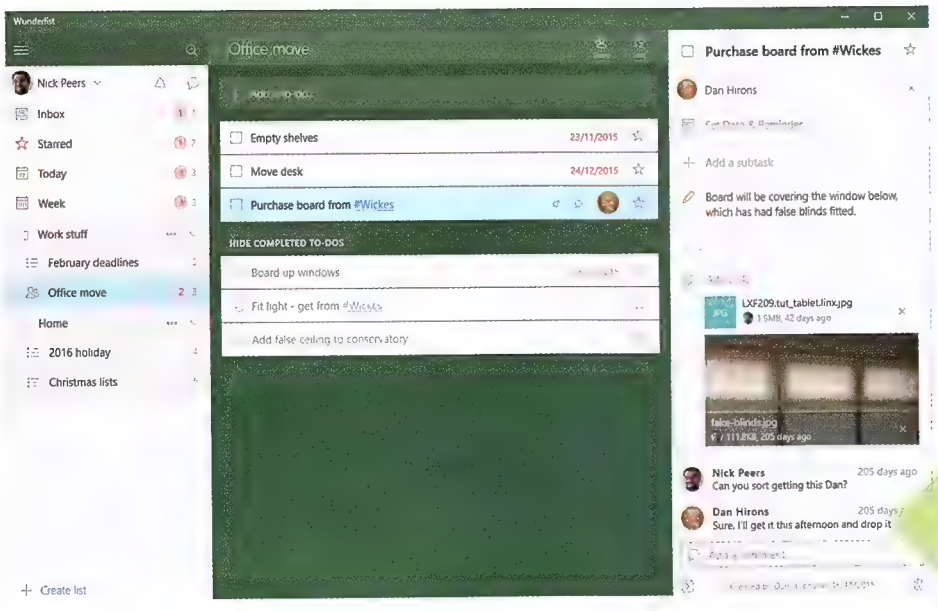
Make stunning presentations

Looking for an original way to showcase your last holiday, or share a family story? Perhaps you want to wow someone with a presentation. **Microsoft Sway** (free, Microsoft Store) enables you to blend together text, photos, videos and other elements — such as embedded maps — in an eye-catching presentation you can share online. It does all the hard work of laying them out, too.



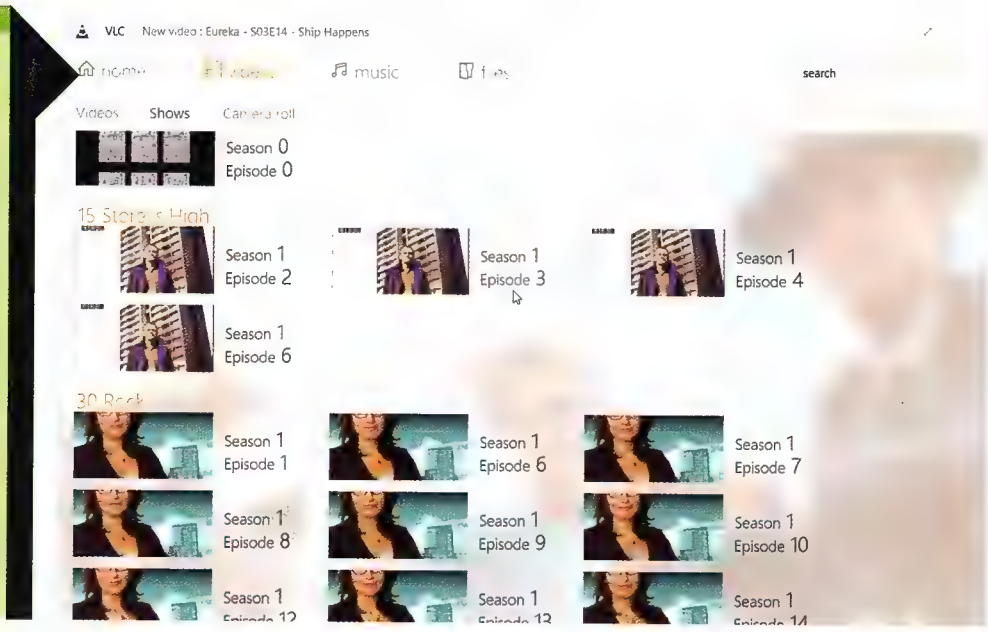
Project-manage with ease

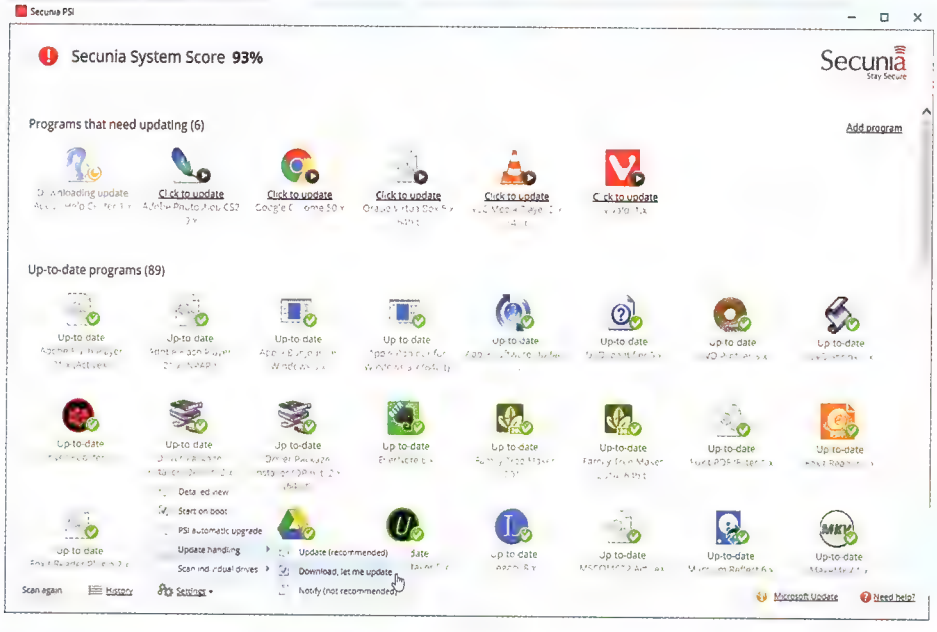
Wunderlist (free, Microsoft Store) is a powerful cross-platform tool that makes it easy to plan and manage everything from small tasks to huge projects in one place. Everything's organised into folders, lists and to-do items, all of which can be assigned to individuals, with deadlines, notes, attachments and more. You'll never have to remember anything again.



Play any video

Want to be able to play just about any video file without having to find a suitable player? Install **VLC for Windows** (free, Microsoft Store) and you can add your music and video libraries and play pretty much any format you come across. Need to play DVD videos too? Install the desktop version from **www.videolan.org/vlc** instead.



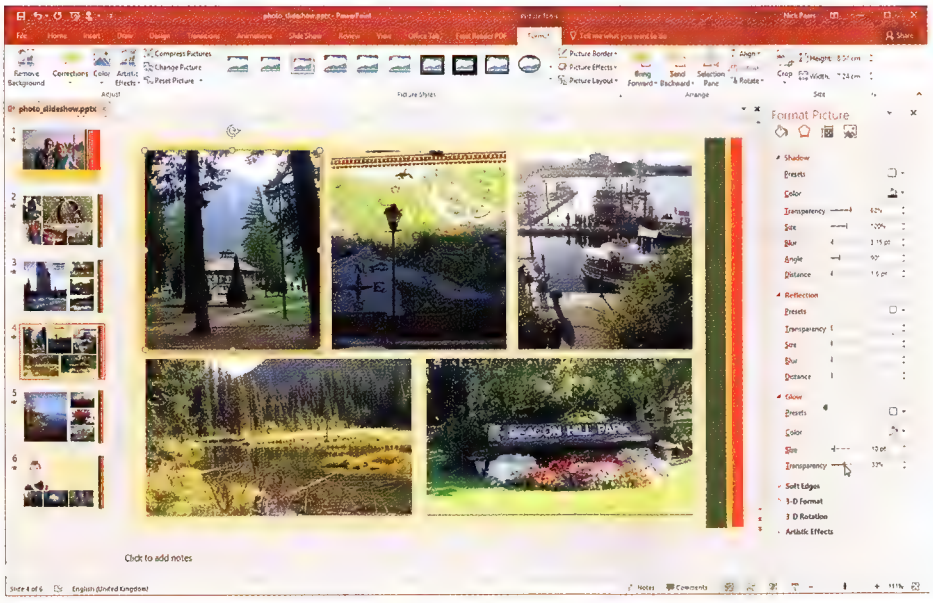


Keep apps up to date

Free software updates don't just fix bugs and plug security holes, they often add new features, too. Make sure you're not missing out by installing **Personal Software Inspector** (free, **bit.ly/softinspector**). It can silently keep apps updated in the background, or you can configure it to alert you when updates become available so you stay in full control of the process.

Remove programs thoroughly

Once you've installed a few of these great apps you may discover one or two you don't really use. Make sure they're completely removed — along with other unwanted apps — with the help of **IObit Uninstaller** (free, **www.iobit.com/en/advanceduninstaller.php**). Its powerful scan removes leftover files and Registry entries — just make sure you untick the option to install the full Advanced SystemCare suite during installation.

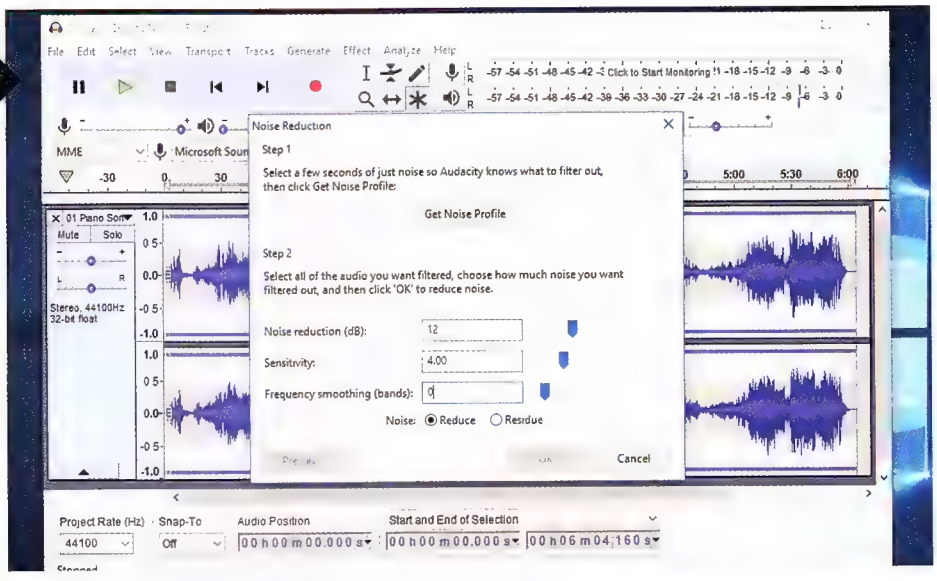


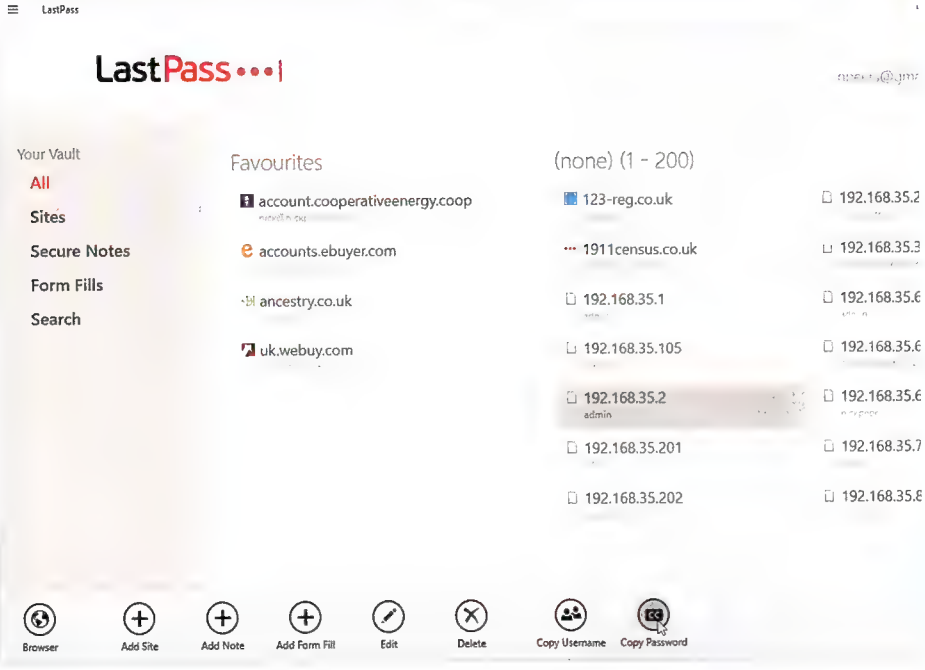
Office for all the family

Free office suites are all well and good, but **Microsoft Office 365 Home** ($129, or $13/mo, **www.office.com**) is exceptional value considering it covers five PCs and Macs in your home, plus gives you 1TB storage on OneDrive. You get the latest versions of Office, plus you can install powerful mobile versions on up to five tablets and five phones, too.

Record and edit audio

Want to record narration or edit an existing audio file? The best tool for the job is **Audacity** (free, **www.audacityteam.org**). You can record through a mic, capture streaming audio or — with the right cables — capture sound from an external source such as a cassette player or turntable. Then use Audacity's powerful tools to trim, edit and fix noise-related issues like hiss.


Noise Reduction
Step 1
Select a few seconds of just noise so Audacity knows what to filter out, then click Get Noise Profile:
Get Noise Profile
Step 2
Select all of the audio you want filtered, choose how much noise you want filtered out, and then click 'OK' to reduce noise.
Noise reduction (dB):
Sensitivity:
Frequency smoothing (bands):
Noise:
Reduce
Residue
Cancel
Project Rate (Hz)
Snap-To
Audio Position
Start and End of Selection

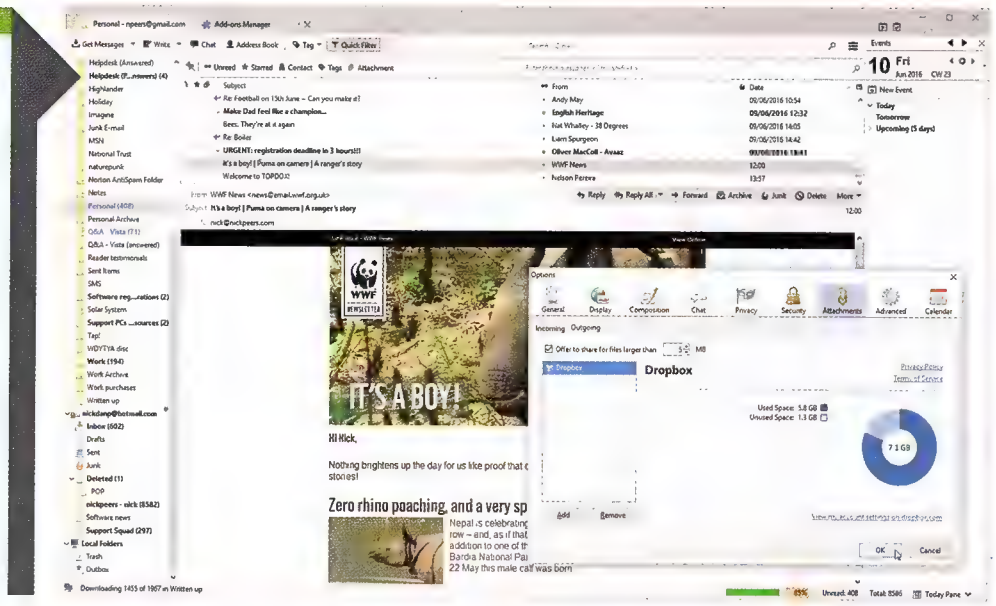


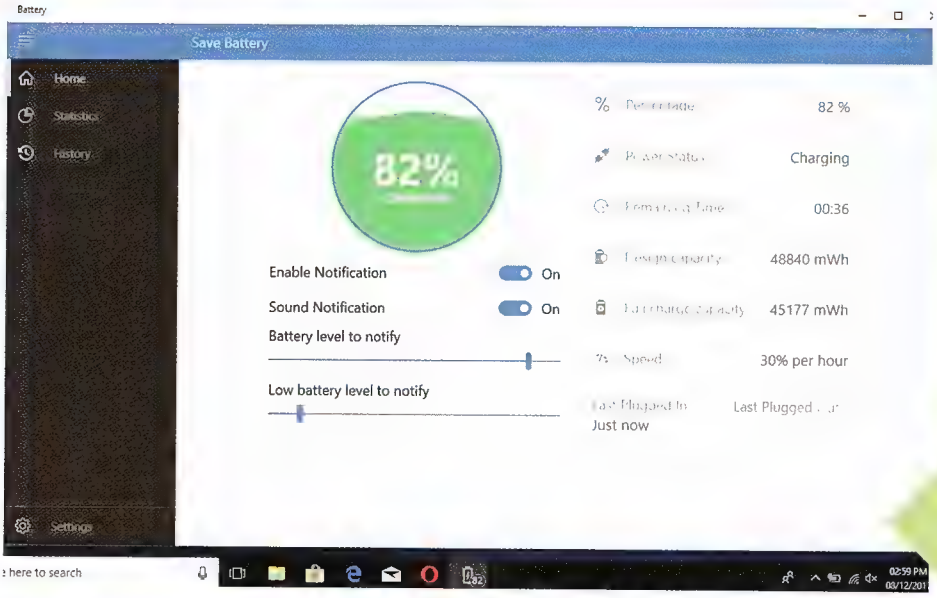
Manage your passwords securely

If you use LastPass Premium (US$24/year, **www.lastpass.com**) to keep your online passwords safe and easy to access, but don't want to have to open your browser to get at them, install the **LastPass** app (free, Microsoft Store). This enables you to view your passwords, secure notes and form fillers — copy and paste them into another app window, plus edit them, too.

Manage your email

Looking for a versatile email client that works with just about any email account? **Thunderbird** (free, **www.getthunderbird.com**) offers all the core functionality you need, plus some handy extras like linking large email attachments (via third-party plug-ins) to your cloud storage, making them easy to share with others without clogging up inboxes.



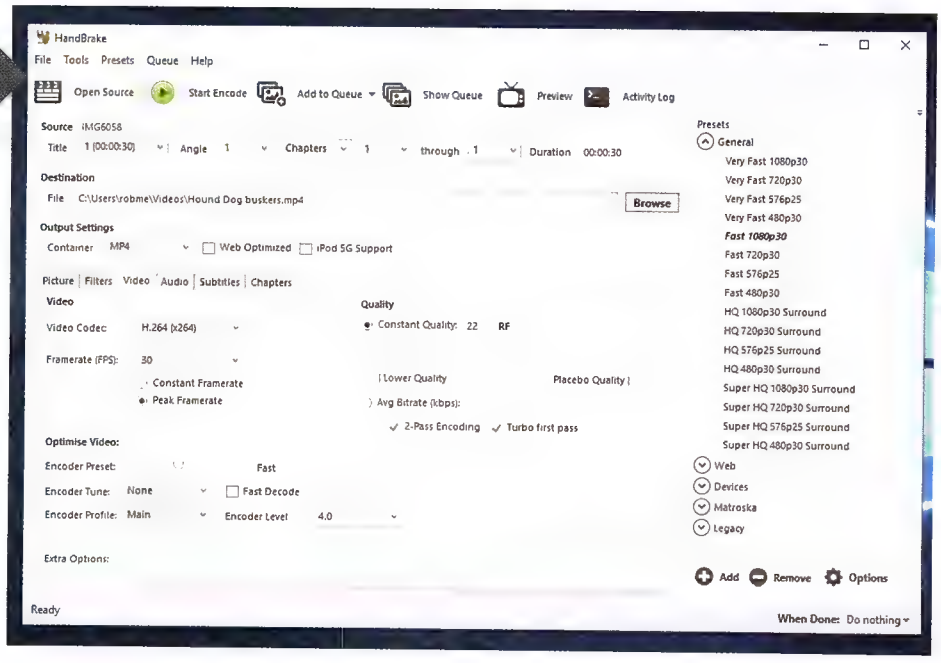


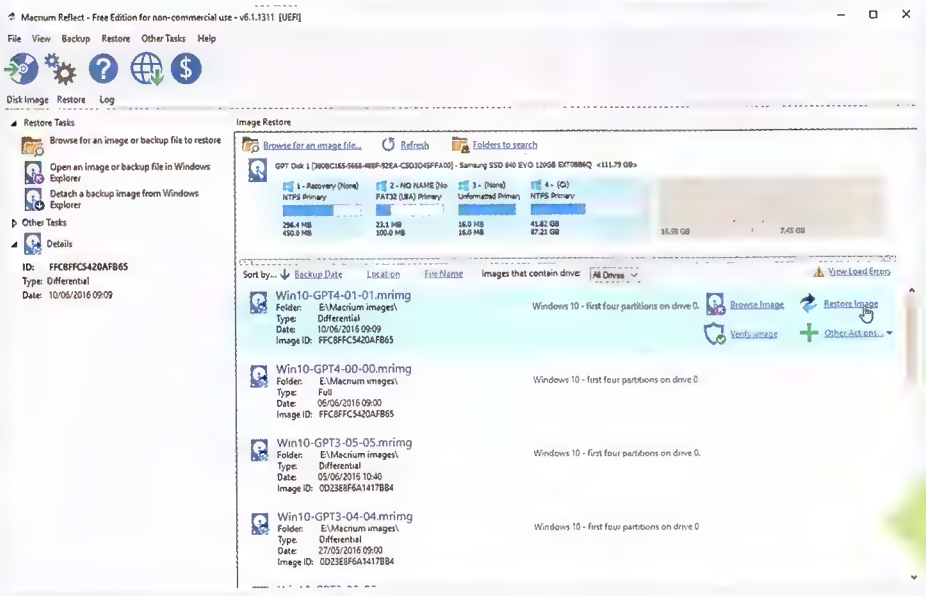
Detailed battery stats

The Battery taskbar notification area icon provides basic detail about your laptop's battery. Install **Save Battery** (free, Microsoft Store) and you can access lots more useful detail, such as when it was last plugged in, its discharge rate and overall health. You can set battery alerts too, but the history feature requires upgrading to the Pro version ($1.19).

Rip and convert video

Sometimes you need video files in a specific format so they'll work with your phone or another device. MP4 is the most common format around, and **Handbrake** (free, **www.handbrake.fr**) can convert video from most formats into MP4 — it can even be used to quickly optimise video for playback on specific devices, too.



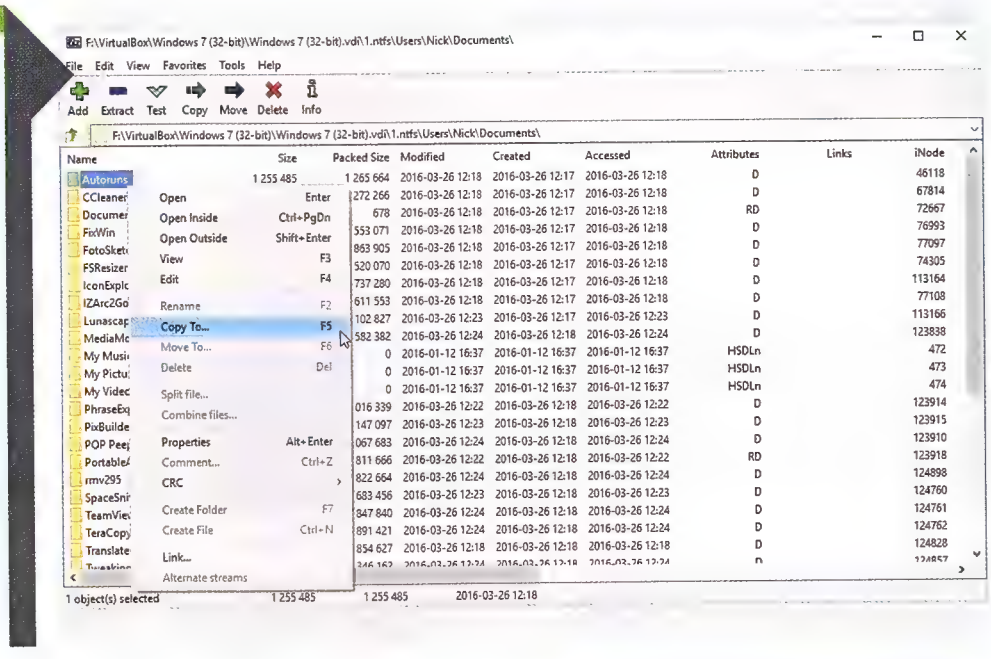


Take a failsafe backup

What happens if you're forced to reinstall Windows? Even if your data is backed up or stored on a different drive, the time taken reinstalling all your programs and settings after the event can take hours. Take a full system image using **Macrium Reflect Free** (free, **www.macrium.com/reflectfree.asp**) and you need never worry about losing programs, settings or data again.

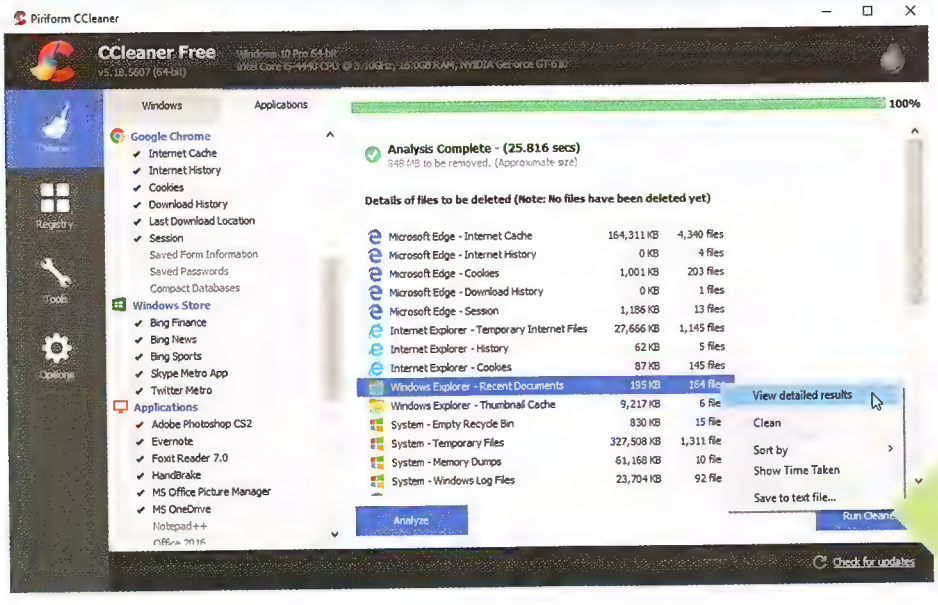
Open any compressed file

Open any compressed file Windows 10 ships with built-in support for ZIP files, but what happens if you come across a different kind of compressed file — such as .rar or .7z? Don't worry, **7-Zip** (free, **www.7-zip.org**) will enable you to not only access these file archives, it can also peek inside virtual drives and create archives in common formats, too.



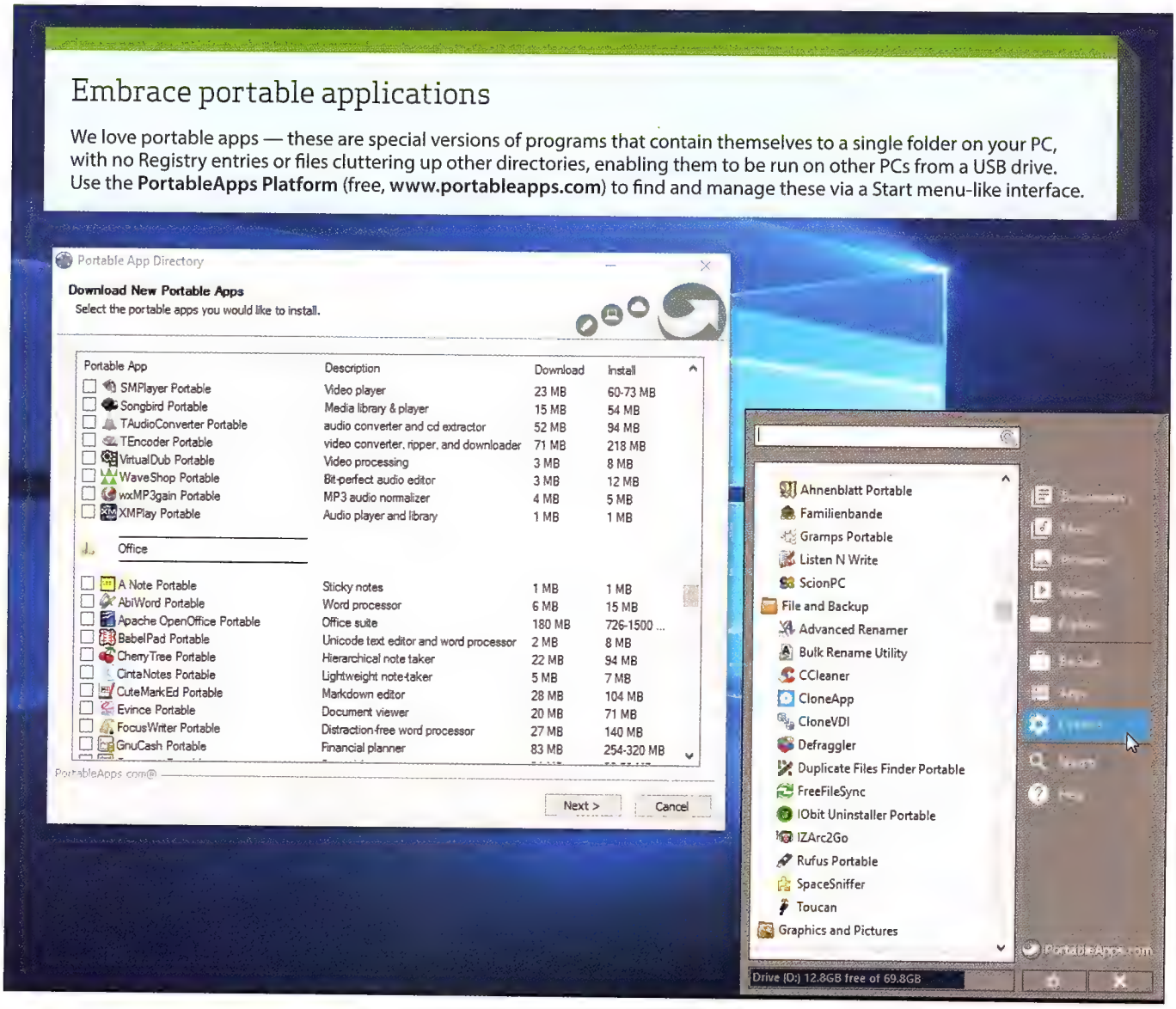
Clean out your PC

We often need reminding to keep storage drives free from clutter, so it keeps your PC running as efficiently as possible. Trimming startup programs and cleaning out various parts of your computer will help achieve maximum speed. **CCleaner** (free, **www.piriform.com**) will help you stay on top of system maintenance and prevent slowdown.


Piriform CCleaner
CCleaner Free
Windows Applications
100%
Google Chrome
Internet Cache
Internet History
Cookies
Download History
Last Download Location
Session
Windows Store
Applications
Analysis Complete - (25.816 secs)
Details of files to be deleted (Note: No files have been deleted yet)
Microsoft Edge - Internet Cache 164,311 KB 4,340 files
Microsoft Edge - Internet History 0 KB 4 files
Microsoft Edge - Cookies 1,001 KB 203 files
Microsoft Edge - Download History 0 KB 1 files
Microsoft Edge - Session 1,186 KB 13 files
Internet Explorer - Temporary Internet Files 27,666 KB 1,145 files
Internet Explorer - History 62 KB 5 files
Internet Explorer - Cookies 87 KB 145 files
Windows Explorer - Recent Documents 195 KB 164 files
Windows Explorer - Thumbnail Cache 9,217 KB 6 file
System - Empty Recycle Bin 830 KB 15 file
System - Temporary Files 327,508 KB 1,311 file
System - Memory Dumps 61,168 KB 10 file
System - Windows Log Files 23,704 KB 92 file
View detailed results
Clean
Sort by
Show Time Taken
Save to text file...
Analyze
Run Cleaner
Check for updates

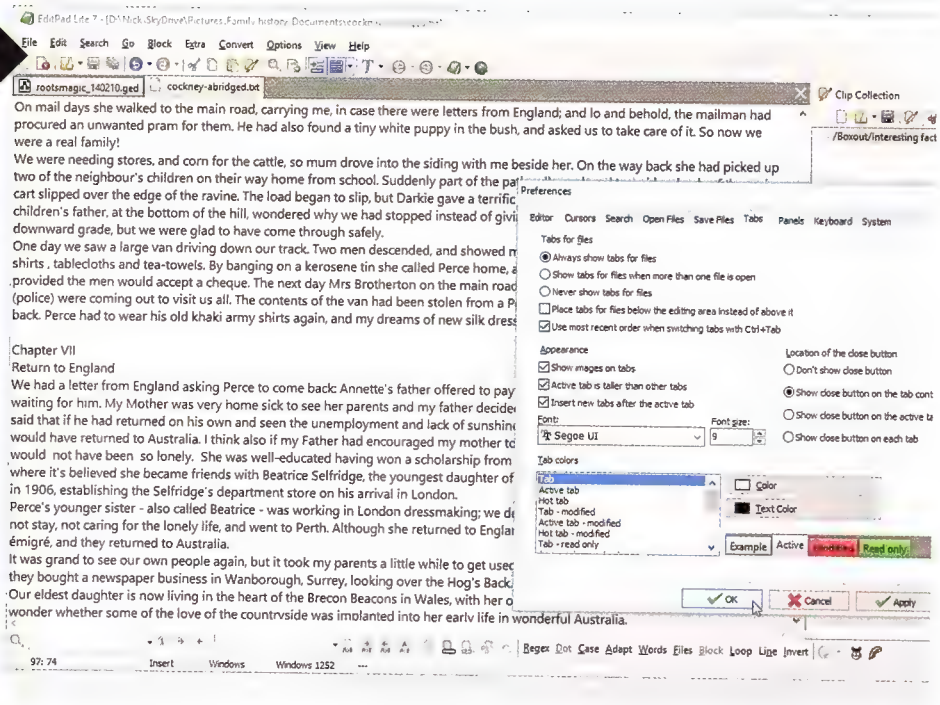
Embrace portable applications

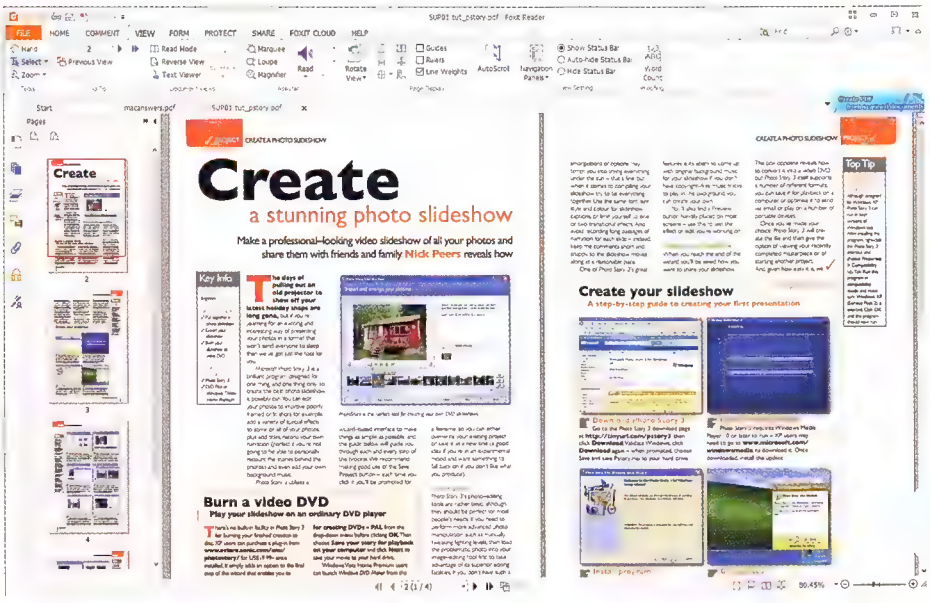
We love portable apps — these are special versions of programs that contain themselves to a single folder on your PC, with no Registry entries or files cluttering up other directories, enabling them to be run on other PCs from a USB drive. Use the **PortableApps Platform** (free, **www.portableapps.com**) to find and manage these via a Start menu-like interface.



Edit text with style

Notepad is fine for basic text-editing, but if you're looking to step up, then **EditPad Lite** (free for personal use, **www.editpadlite.com**) is an essential upgrade. Open multiple files in tabs and switch between them, enjoy unlimited undo and automatic backups as you type, plus store multiple text snippets for easy access via the Clip Collection.



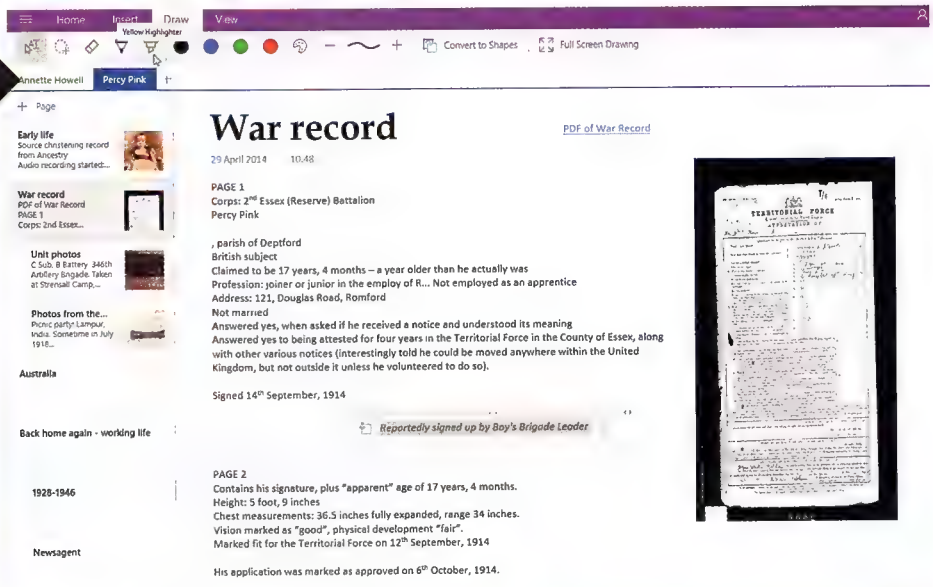

Create
a stunning photo slideshow
Make a professional-looking video slideshow of all your photos and share them with friends and family Nick Peers reveals how
Key Info
Burn a video DVD
Play your slideshow on an ordinary DVD player
Create your slideshow
A step-by-step guide to creating your first presentation
Top Tip

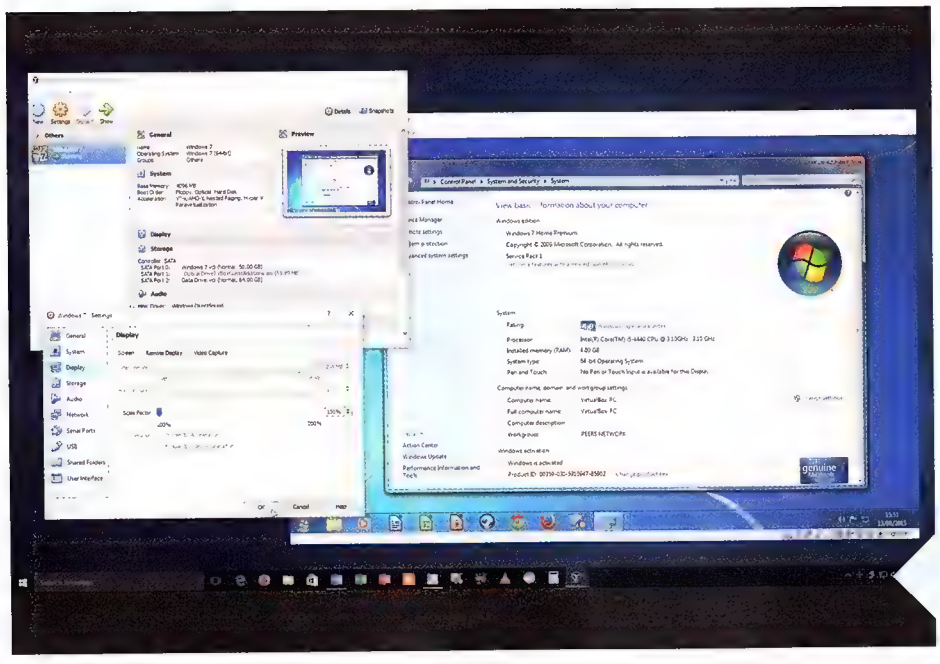
View and create PDFs

PDFs ensure that documents you share look the same on whichever computer or platform they're viewed on. These days, all good free PDF reader tools can create PDFs from other sources, too, and our current favourite is **Foxit Reader** (free, **www.foxitsoftware.com**), which also has the benefit of being light on system resources and it's extremely fast as well.

Super-powered note-taking

Simplenote is great for quick notes, but if you want a fully featured digital notebook with support for annotations, photos, lists and even freehand sketches, then **Microsoft OneNote** (free, Microsoft Store) is a better bet. You can even transfer content from other apps, services and websites via a variety of third-party tools (including Microsoft Edge).


Home
Insert
Draw
View
Annette Howell
Percy Pink
Page
Early life
War record
Unit photos
Photos from the...
Australia
Back home again - working life
1928-1946
Newsagent
War record
PDF of War Record
29 April 2014 10:48
PAGE 1
Corps: 2nd Essex (Reserve) Battalion
Percy Pink
, parish of Deptford
British subject
Claimed to be 17 years, 4 months – a year older than he actually was
Profession: joiner or junior in the employ of R... Not employed as an apprentice
Address: 121, Douglas Road, Romford
Not married
Answered yes, when asked if he received a notice and understood its meaning
Answered yes to being attested for four years in the Territorial Force in the County of Essex, along with other various notices (interestingly told he could be moved anywhere within the United Kingdom, but not outside it unless he volunteered to do so).
Signed 14th September, 1914
Reportedly signed up by Boy's Brigade Leader
PAGE 2
Contains his signature, plus "apparent" age of 17 years, 4 months.
Height: 5 foot, 9 inches
Chest measurements: 36.5 inches fully expanded, range 34 inches.
Vision marked as "good", physical development "fair".
Marked fit for the Territorial Force on 12th September, 1914
His application was marked as approved on 6th October, 1914.



Run virtual machines

Virtual PCs enable you to run older and alternative operating systems like Windows 7 or even XP — they're a great way to continue using older software (and some USB hardware) that's no longer compatible with Windows 10. All you need to supply is a legal copy of Windows, then run **VirtualBox** (free, **www.virtualbox.org**) along with the Extensions Pack. ■

how to

» QUICK TIPS

Experts solve your computing problems

APC and its readers can be one giant helpdesk. If you have a technical problem, chances are one of us can solve it.

WINDOWS

RECOVER DATA AND SETTINGS FROM BACKUP

I've backed my computer up with Macrium in order to fix my non-booting PC, but can you tell me how I recover data from the fail-safe Macrium drive image I took, please?

Anthony Parsons

First, reinstall Macrium Reflect Free. Then follow the step-by-step guide to recover files from your image – when done, right-click the drive icon in File Explorer under This PC and choose 'Macrium Reflect > Unmount Macrium Image'.

Open drive image: Browse to the folder containing your fail-safe drive image. You should see that it's marked as a 'Disk Partition image' with a blue drive icon. Simply double-click the drive image and click Yes when you're prompted to open it with Macrium Reflect Free. The Backup Selection window will open. Tick the largest partition – your Windows drive – and be sure to tick 'Enable access to restricted folders' to bypass permission issues. Click OK. Macrium Reflect Free will assign a drive letter and open the image.

Recover files: You can now browse the image's contents like any other drive, then simply copy off any files you wish to recover to a folder on your new storage media. Open 'Users > [Username]' to locate your personal data, such as documents and photos.

Find program settings: Your user folder also contains an AppData folder – look inside the Local, LocalLow and Roaming folders for program folders containing your settings. Also look inside ProgramData and both Program Files folders on the drive root.

Nick Peers

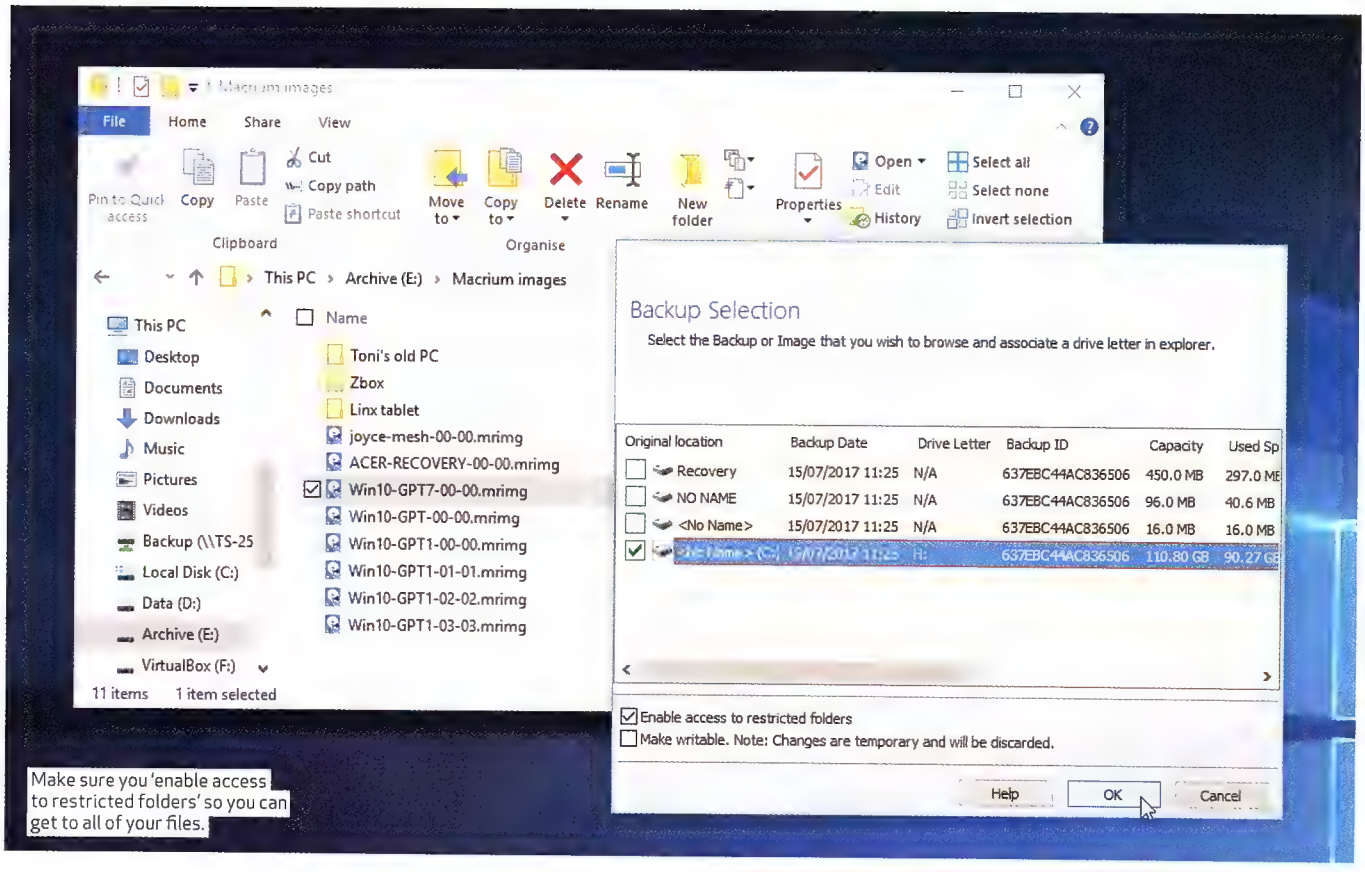
MAC

MY BACKUPS HALT IN SIERRA

I upgraded to a 27-inch iMac with a 1TB Fusion Drive, but every time it tries to run a Time Machine backup, the process stalls at the same point. I have even bought a new external hard drive, but it won't complete the first backup to that either. Is Time Machine broken in Sierra?

Mike Thompson

Some users have reported problems backing up with Time Machine, but most of these issues can be fixed. If you can, archive the drive containing your old backups and switch to using the new one, starting afresh with it. Ensure that Sierra is fully up to date, and that there's ample free space on the external drive to perform a full backup, as well as incremental backups thereafter. It's also wise to check that any migration from your old Mac didn't bring old or buggy software across to your new one,



particularly extensions and enhancements. Turn off Time Machine, connect the new external drive, and restart in macOS Recovery. Using Disk Utility there, run First Aid on your Fusion Drive, then initialise the external drive to Mac OS Extended (Journaled) format. Restart your Mac as normal. In Time Machine's preferences, click Options and add any folders you don't wanted backed up to the exclusions. Re-enable Time Machine to back up to the new drive. Leave the iMac alone to back up, running no apps; overnight is ideal. If Time Machine sticks again, Sierra's Console isn't much help in diagnosing it. You could try to use Recovery to reinstall Sierra, erase the new back-up drive, and then try again.

Howard Oakley

After re-enabling Time Machine, leave your iMac alone (preferably overnight) while it backs up.

LINUX

GUMMIBOOT GONE

I started using the Gummiboot boot manager on my UEFI computer. However, this has now been assimilated into the systemd collective, which I have no desire to install on any of my hardware. That was fine as long as it was still available separately, too, but that's no longer the case. I have two questions for you. First, is it possible to continue using Gummiboot without systemd? Second, if not, what alternatives are there?

Anthony Williamson

Gummiboot will continue to work for you. It has a simple job, to present you with a list of kernels or OSes to boot. The job doesn't change so you can continue to use it. The only concern is if a security vulnerability is found: as Gummiboot is unmaintained, it will not be fixed. It's possible to extract the boot manager from systemd and install that without using systemd itself, although this may not always be possible. Another alternative is to switch to a different manager, such as rEFInd (**www.rodsbooks.com/refind**). With UEFI, the kernel itself becomes the bootloader, so programs like Gummiboot and rEFInd only need to manage the options without the complexities of a full bootloader like GRUB. UEFI computers provide their own boot menu that can be used as a very basic boot manager, or it can be used to choose one, so installing rEFInd alongside Gummiboot isn't only possible, it's recommended as that gives you a fallback while getting used to rEFInd. The web page includes installation instructions but most distros now have rEFInd in their repos.

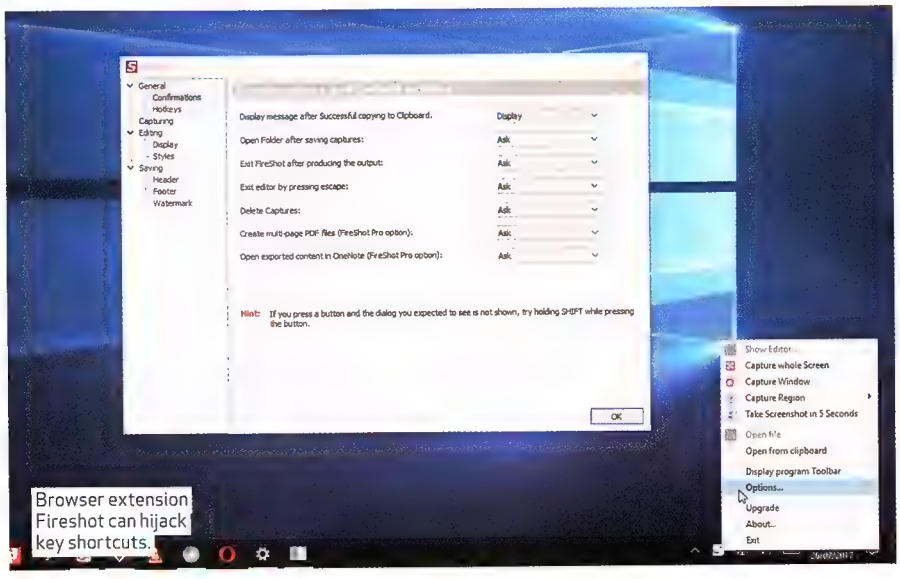
After installing, run:

```
$ sudo refind-install
```

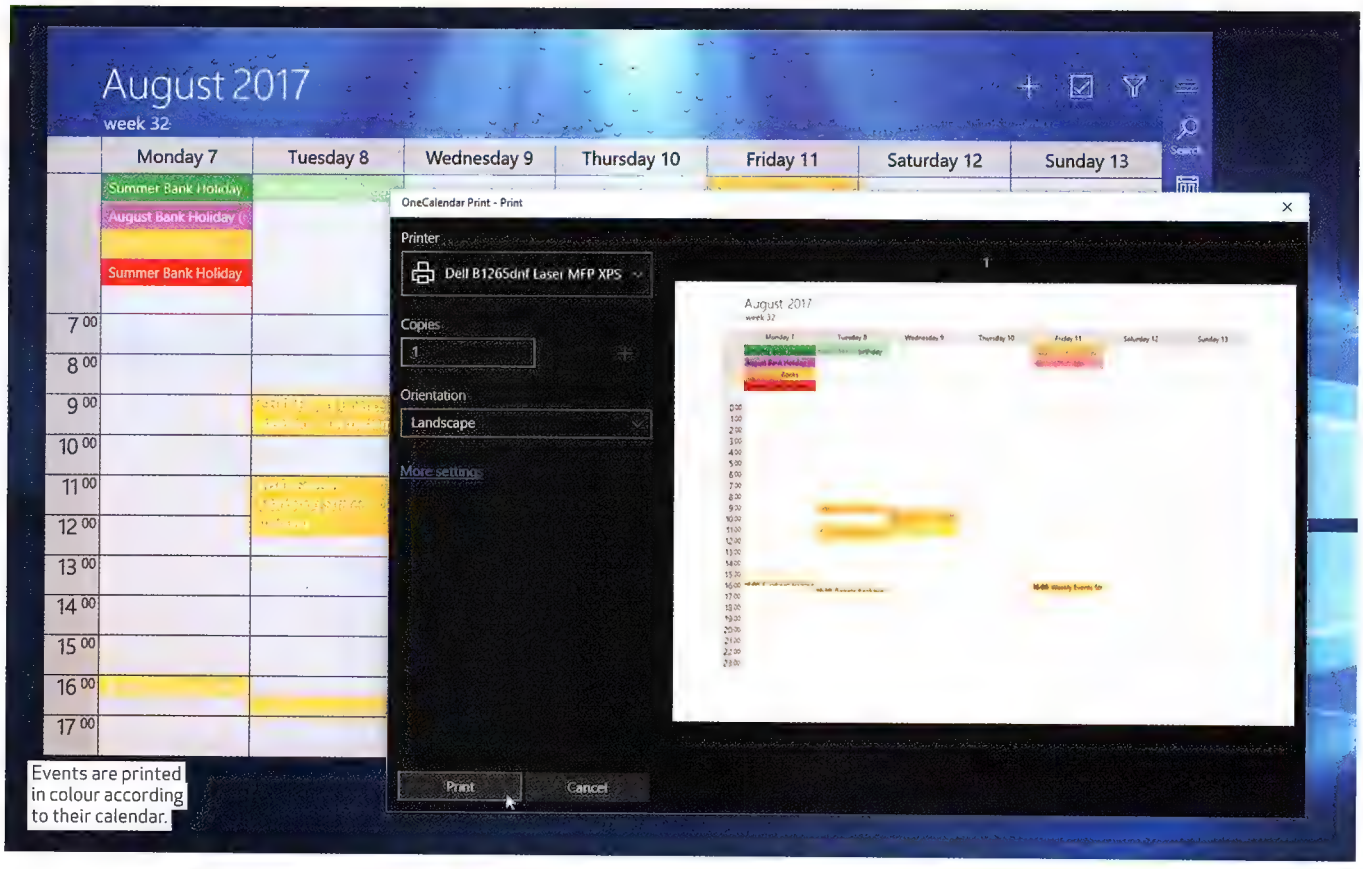
This installs it to the UEFI partition and sets it as the default bootloader. It also retrieves the options used to boot the running system and adds

rEFInd
Boot Management
Boot EFI\ubuntu\grubx64.efi from ESP
Automatic boot in 3 seconds
Use arrow keys to move cursor; Enter to boot;
Insert or F2 for more options; Esc to refresh

rEFInd is a UEFI boot manager that isn't tied to any controversial Linux software.



Browser extension Fireshot can hijack key shortcuts.



them to the configuration. You can now reboot and try it, knowing that if anything goes wrong, you still have Gummiboot. There are two configuration files that control rEFInd's behaviour. The main one is at EFI/refind/refind.conf and is heavily commented. The options here mainly control the appearance and behaviour of the menu. The other file is /boot/refind_linux.conf that contains the kernel options for the Linux menu entries. This was created by refind-install using your existing boot options and is used whenever booting a Linux kernel. You can create manual configurations but this is generally unnecessary, the auto-detection is good. That also means that you don't need to run anything after adding or removing a kernel, rEFInd picks up changes automatically, unlike Gummiboot or GRUB.

APC Team

INTERNET
BROWSER ADD-ON HIJACK

I was looking for a browser extension to capture a screenshot of an entire web page and settled on Fireshot, but after a recent update, I've found it's now somehow installed itself to my Taskbar Notification area. How do I now get rid of this?

Tim Ellis

This is rather sneaky behaviour, as Fireshot has added a desktop instance of itself, which basically runs whenever your browser is open.

> "One Calendar isn't smart enough to recognise read-only calendars and prevent you from saving changes to them. The solution is to contact the calendar's owner and ask for full access."

You can close this manually without closing your browser via its Taskbar Notification area icon, but you can't remove it permanently.

If this is a dealbreaker – it was for Tim as the program hijacked key shortcuts from other programs – then you'll need to remove Fireshot completely. Tim was using Firefox, so we instructed him to type "about:addons" into the Address Bar. Locate Fireshot and click Remove, restarting Firefox to complete the process.

Ian Sleightholm

SOFTWARE
ONE CALENDAR PROBLEMS

I bought the One Calendar app after it being recommended to me by a friend. It's a big improvement over the built-in app in Windows, but although I can colour-code events on screen, only one colour appears when printing. I also get a sync error message at the top of the screen — I thought I'd paid for the full version.

Tony Lawrence

We'd purchased One Calendar, so knew this wasn't normal behaviour. We tracked down the sync error problem to the fact that Tony had been attempting to save events to a read-only calendar, typically one shared by another user – One Calendar isn't smart enough to recognise read-only calendars and prevent you from saving changes to them. The solution is to contact the calendar's owner and ask for full access, or log on to your calendar account online to see if there's a setting you can change. Failing that, recreate the event in a calendar that isn't read-only – select the event and click Copy to quickly do this, then delete the original event.

As for the print error, we were unable to replicate this on our PC – basically, One Calendar colours events according to the calendar they're assigned to (change these colours via 'Settings > Options > Colors'). Tony subsequently reported that the print function worked correctly when he set the app up on his laptop, suggesting it

might be related to a printer driver issue on his main PC.
Nick Odantzis

WINDOWS

CAN I RECOVER WINDOWS?

While updating Windows 10, I stupidly switched off, and now it won't boot. It goes through several screens and then halts. I can access the BIOS/UEFI settings and have access to my wife's PC. Can you help me recover my system?
Miles Mead

Download and launch the Media Creation Tool on your wife's PC from **www.microsoft.com/software-download/windows10** – choose to upgrade another PC when prompted, then create bootable media (preferably a USB flash drive). Insert this into your malfunctioning PC and attempt to boot from it – if necessary, enter Settings to make the drive the first bootable device. When you come to the Setup screen, click the Repair option then follow the prompts to access the automatic repair tool to see if Windows can resolve the problem.

If this fails, you may need to try the Refresh option to recover your files, settings and Windows 10 apps (but not desktop programs). Miles subsequently reported success in getting Windows working again.
Nick Peers

LINUX

VNC VS FIREWALL

A colleague of mine was talking about a problem he was having with remote desktops, specifically connecting from a work computer to a remote home computer. I assume the home machine is probably behind a router with a firewall? Would that mean he needs to open a port in this firewall at home before he can connect? Is this risky? Which port is used for VNC?
David Hignett

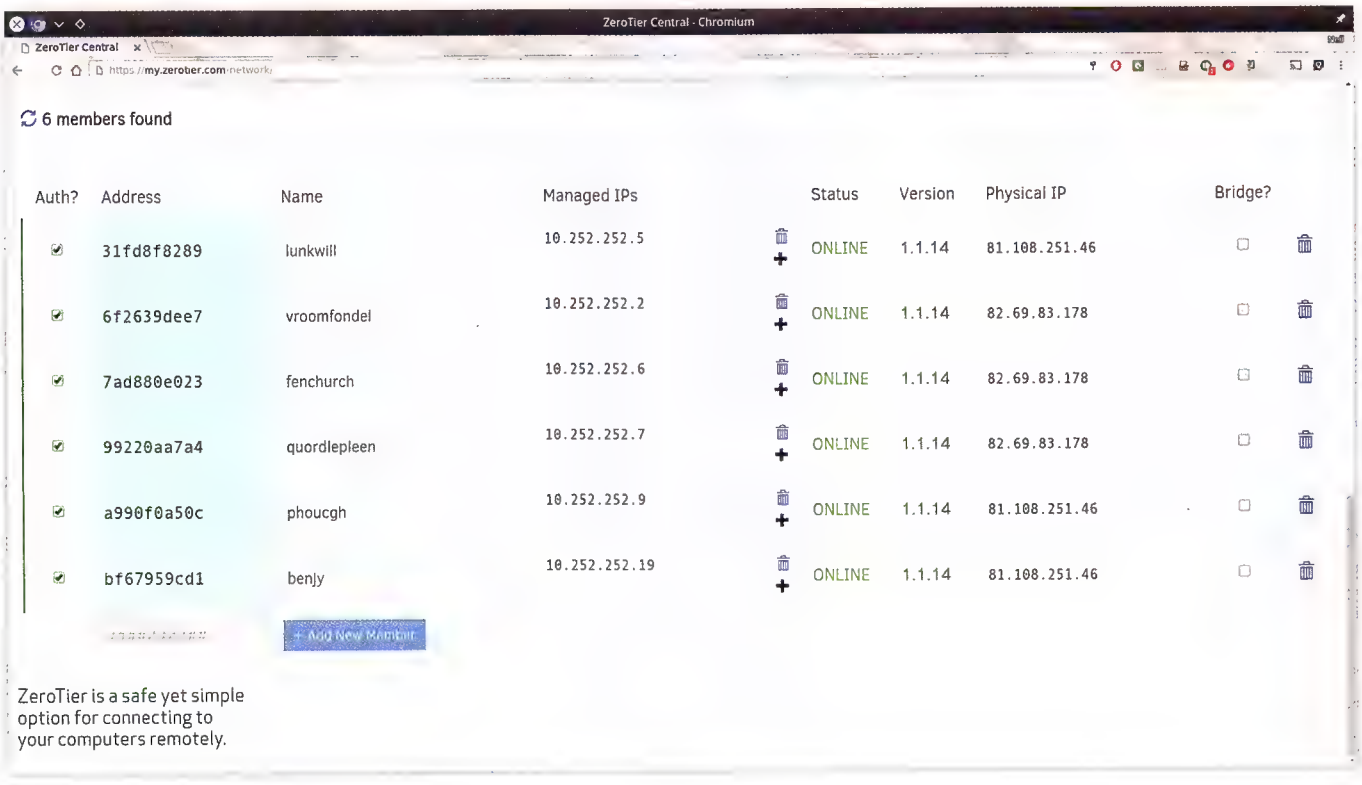
A home computer behind a router is inaccessible from outside by default. It's not just a firewall, Network Address Translation (NAT) on the router means that the external IP address only gets as far as the router. Your colleague needs to set up port forwarding on the router to forward specific ports from the internet to a specific computer. In the case of VNC, the default address uses port 5900. However, this is considered a security risk and will open him up to all sorts of attacks from people trying to find vulnerabilities in the VNC software. A safer approach is to use a VPN (virtual private network) which creates an encrypted tunnel through which the remote computer becomes a part of the home network. We've covered this in the past, but it can be a little tricky to set up. Fortunately, there is now a simpler alternative in the form of the ZeroTier service. This allows you to create a virtual network in your web browser. The first step is to go to **www.zerotier.com** and install the software on both computers. Next, create a network, which you do from the website. This has a 16-character ID, used to add computers to the network. On each computer, run

```
$ sudo zerotier-cli join ID
```

You don't want anyone to be able to connect to your network, so you need to go back to the web control panel at **myzerotier.com**, go to your network and tick the Auth box for each computer. Now each computer has a new IP address that can only be accessed by other authorised computers on your network. All traffic is encrypted and goes directly between your computers and the software only connects to the zeroTier server to get the location of the other computer.

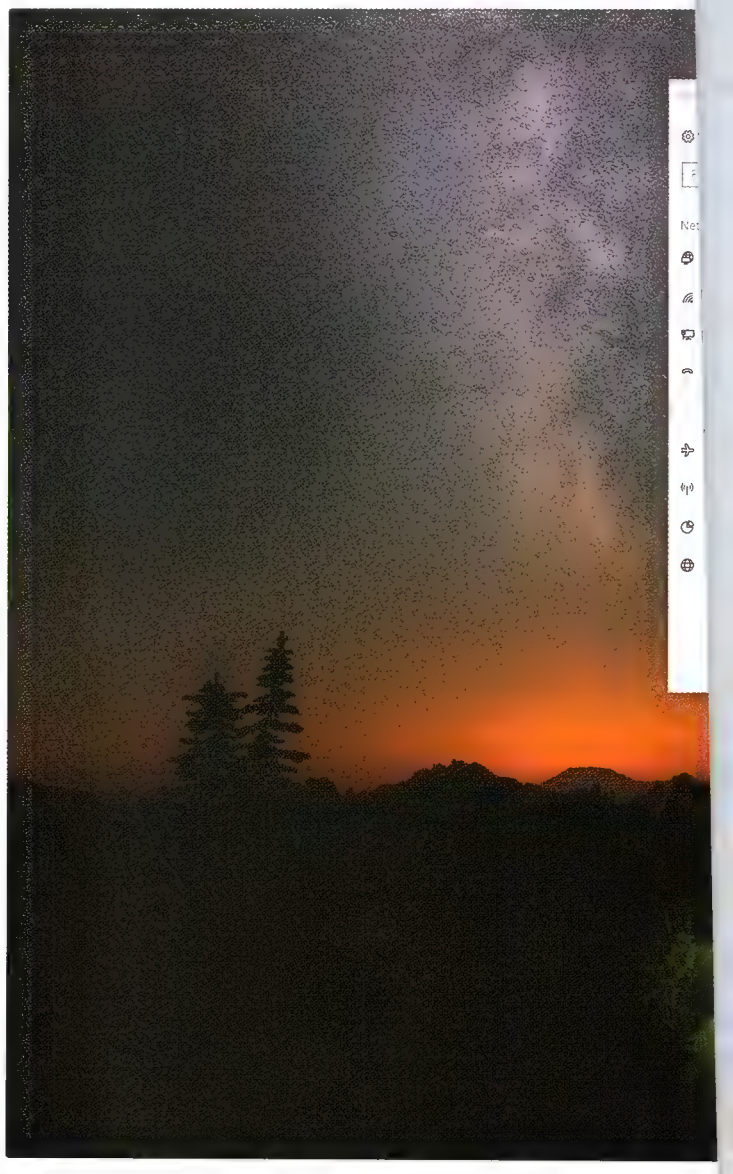
Unlike a VPN, ZeroTier creates a new private network rather than joining a computer to an existing network, so you need to add each computer separately. Apart from that, it's a simple way of safely accessing a computer from afar, and it works with mobile devices too.
APC Team

> **"A VPN (virtual private network) creates an ecrypted tunnel through which the remote computer becomes a part of the home network."**


ZeroTier Central - Chromium
ZeroTier Central
https://my.zerotier.com/network/
6 members found
Auth? Address Name Managed IPs Status Version Physical IP Bridge?
31fd8f8289 lunkwill 10.252.252.5 ONLINE 1.1.14 81.108.251.46
6f2639dee7 vroomfondel 10.252.252.2 ONLINE 1.1.14 82.69.83.178
7ad880e023 fenchurch 10.252.252.6 ONLINE 1.1.14 82.69.83.178
99220aa7a4 quordlepleen 10.252.252.7 ONLINE 1.1.14 82.69.83.178
a990f0a50c phoucgh 10.252.252.9 ONLINE 1.1.14 81.108.251.46
bf67959cd1 benjy 10.252.252.19 ONLINE 1.1.14 81.108.251.46
+ Add New Member
ZeroTier is a safe yet simple option for connecting to your computers remotely.

Master Windows 10's Action Centre

Window 10's Action Centre gives you quick access to important features. Matt Hanson shows how it works.



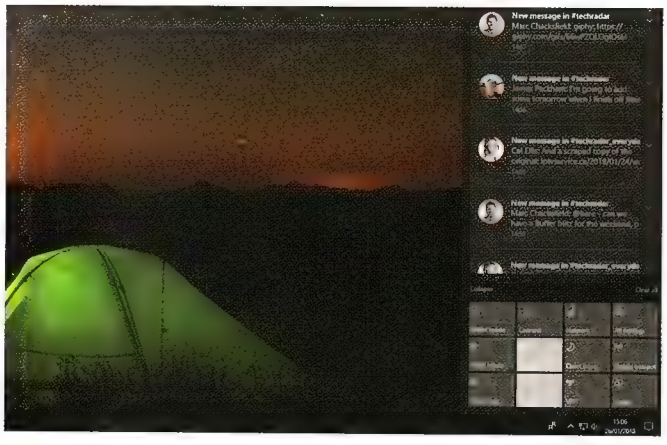
The Action Centre in Windows 10 gives you quick and easy access to important tools and features of the operating system, as well as displaying recent notifications you may have missed. Since its debut with Windows 10 in 2015, Microsoft has continued to work on and evolve the Action Centre, and it is now more feature-packed than ever before, thanks to a range of improvements.

You can also configure Action Centre so it works the way you want it to, and set 'Quiet hours' that stop notifications from popping up onscreen for set amounts of time, enabling you to work without interruption. In fact, there's so much you can do with the Action Centre, that we've compiled this ultimate guide to its best features, as well as exploring the newest additions that have arrived with the major updates to Windows 10.

The Action Centre explained

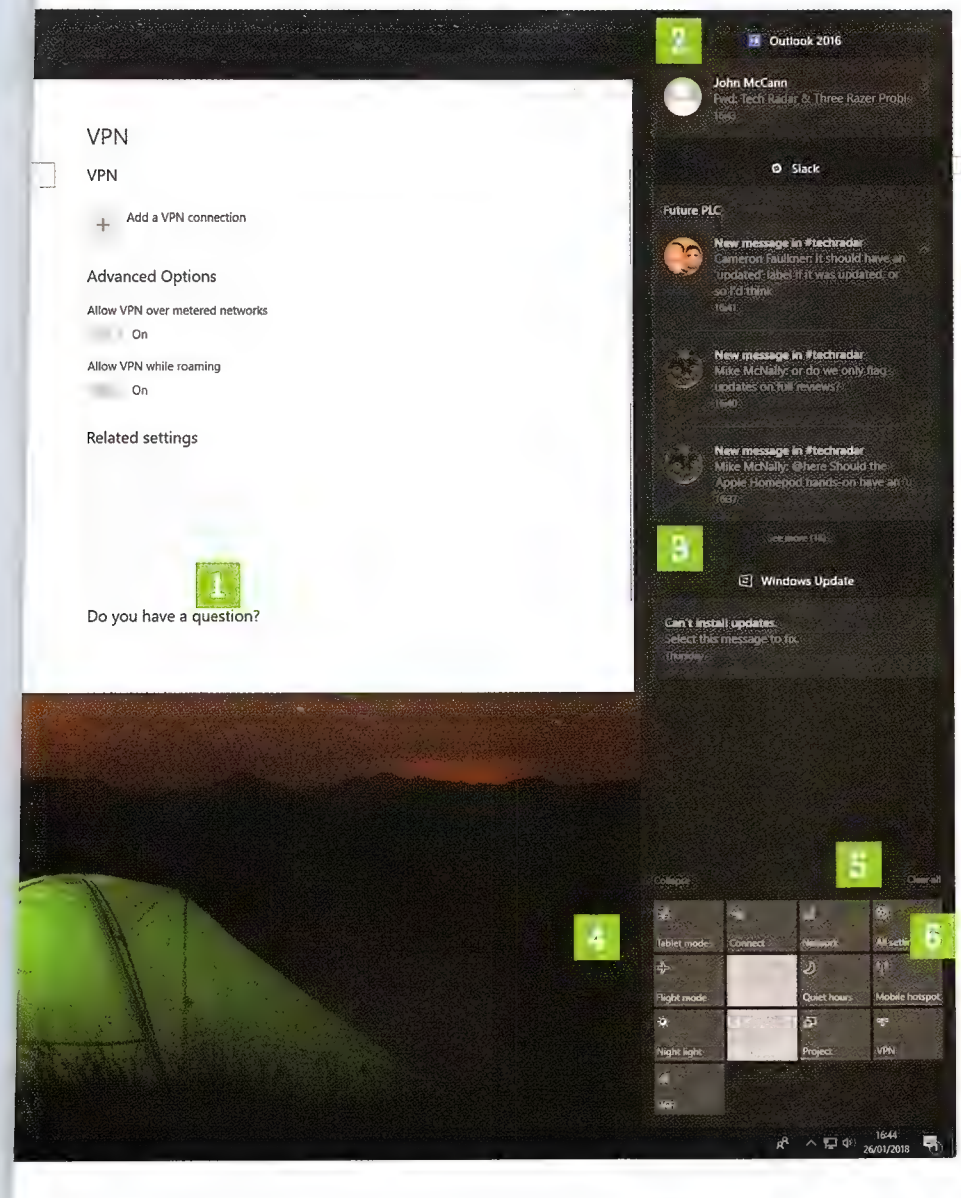
1 OPENING THE ACTION CENTRE

To open the Action Centre, click on its icon on the right-hand side of the Taskbar. The icon is in the shape of a speech bubble, but don't assume that the Action Centre is just about notifications. If you do have unread notifications, the icon will show how many unread ones there are. Click the icon and the Action Centre will appear on the right-hand side of your screen.



2 SEE YOUR NOTIFICATIONS

Notifications in Windows 10 work a lot like they do on your smartphone. When you get an email or instant message, a quick notification will appear on the screen. If you miss a notification, opening the Action Centre will list the most recent notifications that you've received. It will also usefully group those notifications by app, so you can see all your emails at once, for example.



1 WINDOWS
Some buttons on the Action Centre, such as VPN, will open a new window where you can change the settings.

2 APP NOTIFICATIONS
Many apps show notifications, and the most recent ones will be shown in the Action Centre, grouped by app.

3 SEE MORE NOTIFICATIONS
If you have a lot of missed notifications, click and scroll here to see an expanded collection of them.

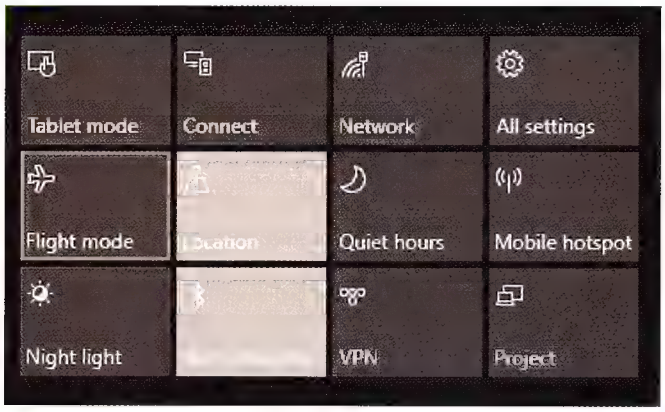
4 TABLET MODE
If you use Windows 10 on a tablet or touchscreen device, you can place it in Tablet mode by tapping this icon.

5 CLEAR ALL
If your Action Centre is filled with lots of notifications, you can quickly remove them all by clicking 'Clear all'.

6 SETTINGS
Action Centre gives you easy access to the Settings app, where you can configure your Windows 10 device.

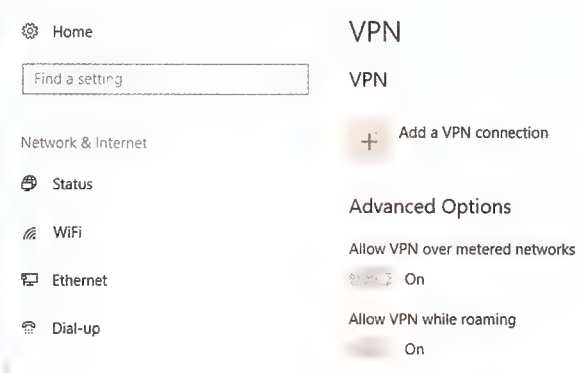
3 MUTING NOTIFICATIONS
Notifications are useful for making sure you don't miss out on important messages, or if your PC needs to alert you to something. There will be times when you don't want notifications popping up. It's easy to mute these by turning on 'Quiet hours', an option at the bottom of the Action Centre that stops Windows 10 from displaying notifications until you turn that option off.

4 SHARE YOUR WI-FI WITH A HOTSPOT
You can turn your Windows 10 device into a mobile hotspot so you can connect other devices via Wi-Fi to your laptop or PC and share its internet connection. To create a mobile hotspot, click the 'Mobile hotspot' icon in the Action Centre. It will then tell you the name of the Wi-Fi network it has created. On your mobile device, you should see the network — click it to connect.



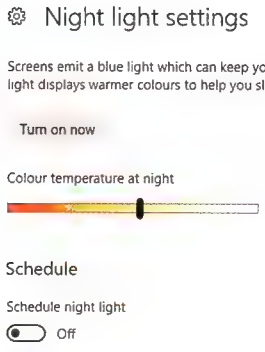
5 CONNECTIVITY OPTIONS

The Action Centre also gives you quick access to various connectivity options, such as turning Bluetooth on or off, and to access nearby Wi-Fi networks. If you want to turn off everything at once — to save your laptop's battery, for example — click Flight Mode, which will disable Bluetooth *and* Wi-Fi. Click Connect to get your PC to search for wireless displays and speakers.



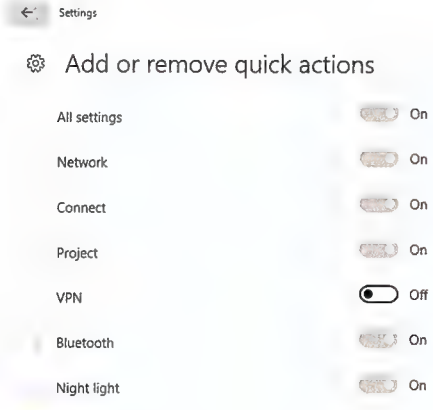
6 QUICKLY CONNECT TO A VPN

The Action Centre also enables you to connect to a VPN. VPNs are great if you want to safely and securely connect to public Wi-Fi networks. They can also be used to mask your location — handy for accessing sites and services in other countries. Click VPN, then 'Add a VPN connection' and enter the details for the VPN you've signed up for.


Night light settings
Screens emit a blue light which can keep you up at night. Night light displays warmer colours to help you sleep.
Turn on now
Colour temperature at night
Schedule
Schedule night light
Off

7 ACTIVATE 'NIGHT LIGHT

If you're using your PC late at night, then turn on 'Night light' in the Action Centre. This tints the screen, and removes blue light, making it more comfortable to use in dark surroundings. It will also help you sleep better, since the blue light normally displayed on screens can affect your natural body clock. For more settings, type 'Night light' into the search box in the Taskbar.



8 CUSTOMISE THE ACTION CENTRE

If you don't use all of the settings the Action Centre gives you access to, you can customise it so it only shows the icons for settings you regularly use. To do this, type "Notifications & actions" into the Taskbar search box and press Enter. A settings window will open. Under 'Quick actions', click 'Add or remove quick actions'. You can then toggle the icons you want to remove off.

Security and Maintenance
Control Panel › System and Security › Security and Maintenance
Control Panel Home
Change Security and Maintenance settings
Change User Account Control settings
View archived messages
Review recent messages and resolve problems
Security and Maintenance has detected one or more issues for you to review.
Security
Network firewall
On
Kaspersky Security Cloud is currently turned on.
View installed firewall apps
Virus protection
On
Kaspersky Security Cloud is turned on.
Internet security settings
OK
All Internet security settings are set to their recommended levels.
User Account Control
On
UAC will notify you when applications try to make changes to the computer.
Change settings

9 WHERE'S THE OLD ACTION CENTRE?

If you've used previous versions of Windows, you may be wondering where the old Action Centre is. This was quite a different tool that helped you make sure your PC was secure. You can find the old version of the Action Centre, and its associated functions, by typing "Security and Maintenance" into the Taskbar's search box — this is the new name for the Action Centre of old.

10 WHAT'S THE FUTURE FOR THE ACTION CENTRE?

Microsoft is continually fine-tuning the Action Centre in Windows 10, adding new features that make using your PC even easier. Rumours suggest that Microsoft will soon move Cortana to the Action Centre, enabling you to turn it on and off from there. It appears that the Action Centre will also offer improved touchscreen gestures — handy for devices such as tablets.

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Find rogue apps slowing down your Mac

Does your Mac feel slower than it used to be? Norman Bean helps you track down the culprits.

All computers slow down over time, for a whole variety of reasons. In recent issues of APC, we've shown you how to address some of these reasons, decluttering your Mac to detox it, for example (APC #447), and speeding up performance on old Macs by switching to the free and open-source elementary OS (APC #442). In an upcoming issue, we'll tackle some common causes of slowdowns in High Sierra, particularly those relating to preferences and the configuration of your system. But first, let's look at probably the most common cause of poor performance in any version of macOS: your apps.

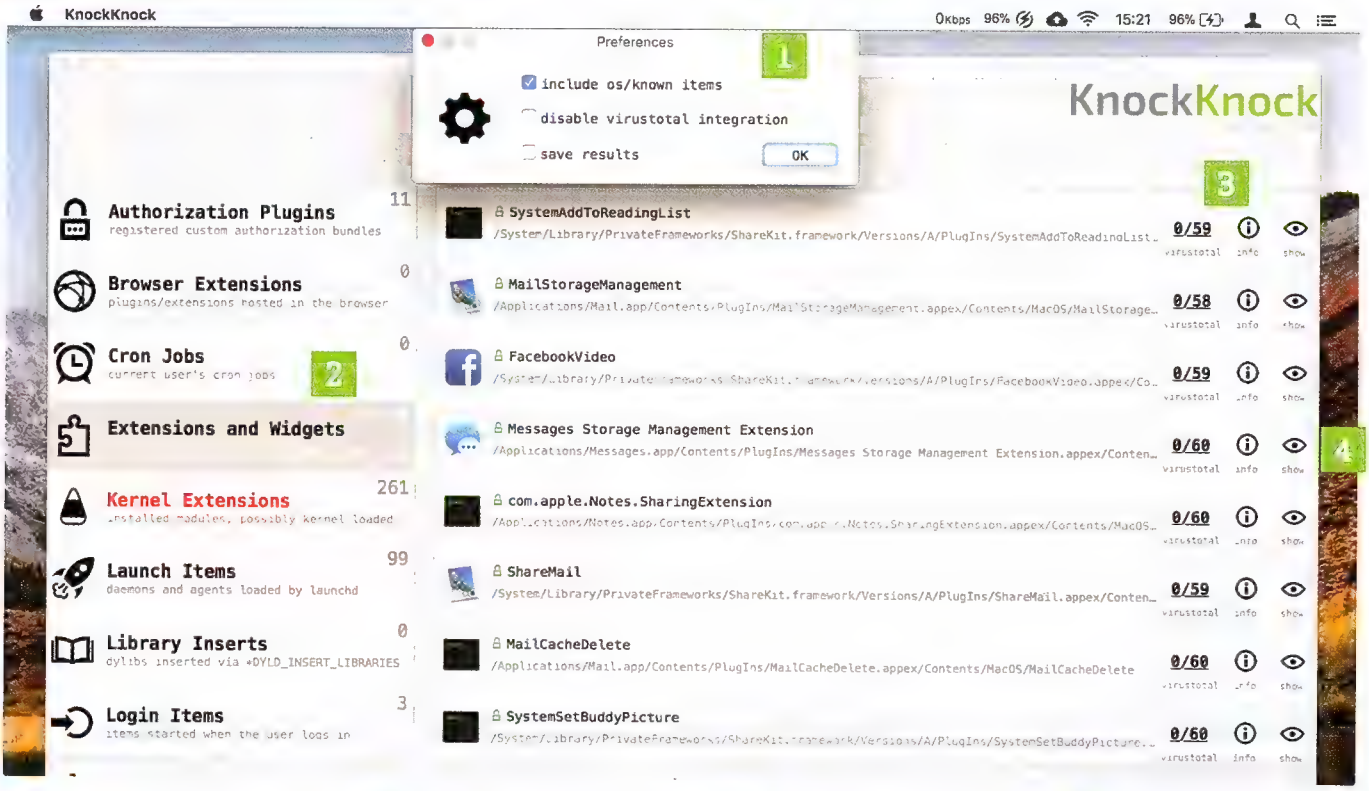
Don't panic! Of course, the whole point of having a computer is to do things with it. But when your Mac seems sluggish, this is often because of apps running in the background, putting an unnecessary load on the CPU or hogging too much memory. If your Mac seems to be taking an eon to start up, this is often because unneeded apps or utilities are loading.

We'll show you how to use your Mac's built-in Activity Monitor to identify such rogue apps, and a handy utility called KnockKnock to find apps that persistently install at startup.

Persistent installation is a typical characteristic of malware, but it's important to note that not all such apps are malware, and KnockKnock will check the apps it finds for you. Either way, of course, you probably don't need them!

One word of advice: occasionally, we recommend utilities for specific tasks (like KnockKnock here), but you should avoid installing general 'cleanup' apps, particularly those promoted in pop-up ads on the web. Few, if any, such apps are updated for the latest versions of macOS, and they usually do more harm than good, hogging resources in the background themselves, or worse.

Use KnockKnock to find files that load at startup



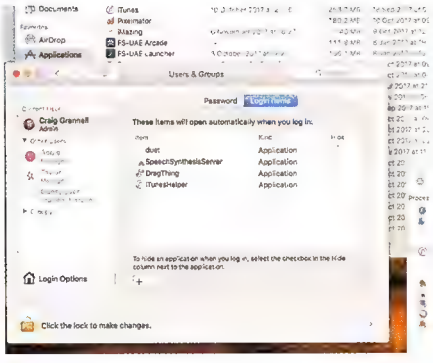
1 SYSTEM FILES
By default only third-party extras, like adware, are listed, but you can opt to show macOS system items, too.

2 CATEGORIES
Many types of item might load when macOS starts up. See how many of each type there are; click one to see those items.

3 MORE INFO
Click an item's VirusTotal score to learn more if any scanners think it may be malware; click the 'i' icon for technical info.

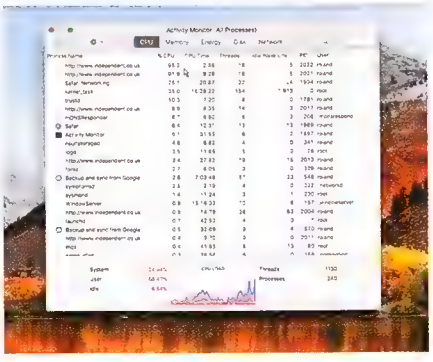
4 SHOW LOCATION
Click the eye icon to see the item in a Finder window. You can trash it from there, or use an uninstaller.

Identify memory hogs and persistent apps



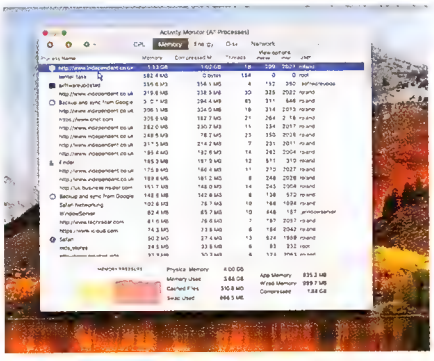
1 CULL LOGIN ITEMS

Open 'System Preferences > Users & Groups', select your account, and click Login Items. If there's an item listed that you don't need every time you log in, click it, then click the minus button below so it won't load on login.



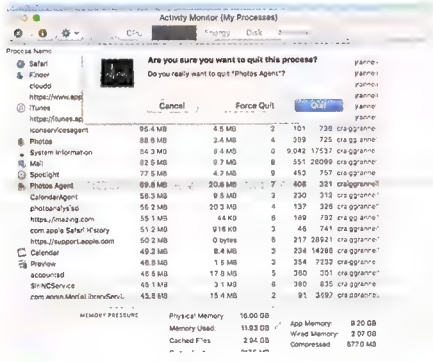
2 CPU USAGE

In Finder, select 'Go > Utilities' and open Activity Monitor. In the View menu, select All Processes, then click the CPU tab. Click the %CPU column header to sort by CPU demand. Here, two web pages are using over 90%.



3 MEMORY USAGE

Use the Memory tab in the same way, clicking the Memory column header to sort by memory usage. Red in the Memory Pressure graph at the bottom is bad — if it's permanent, look into installing more physical RAM.

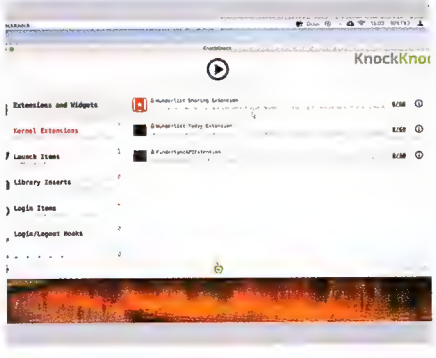


4 QUIT UNRULY APPS

If an app or process is using too much CPU power or memory, or is in red (meaning it is 'unresponsive'), you can close it: click its name, then the X button (top-left). To confirm, choose Quit or, if necessary, Force Quit.

5 KNOCKKNOCK SCAN

Download KnockKnock (free from **objective-see.com**), double-click the Zip to extract the app, then drag it to the Applications folder and launch it. Click the large Scan button at the top, and enter your admin password.

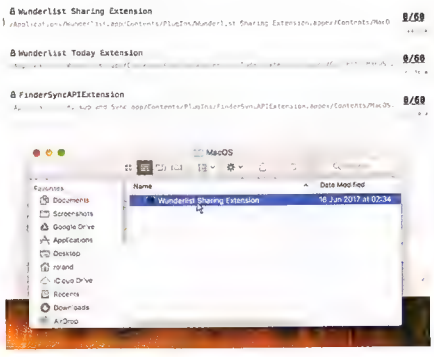


6 CHECK RESULTS

Click each of the categories on the left in turn to view the various persistent items that load and run in the background, possibly slowing down your Mac. Here we found Wunderlist, but a web search verifies it's harmless.

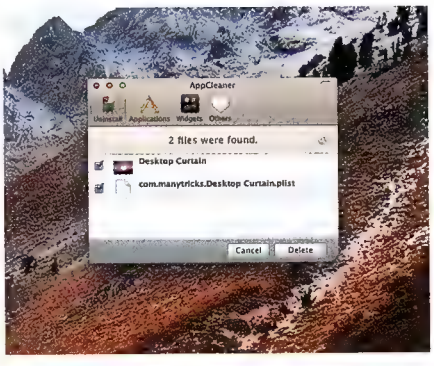
7 CHECK FOR MALWARE

Persistently installed software may be malware, so KnockKnock will automatically check suspicious items with the online VirusTotal service and show a 'detection ratio'. Click this for details and a link to more information.



8 LOCATE ITEMS

The exact path to each item is listed beneath it, but if you decide to remove unwanted items, the easiest procedure is to click the eye icon (far right) next to its name. This opens a Finder window showing the item.

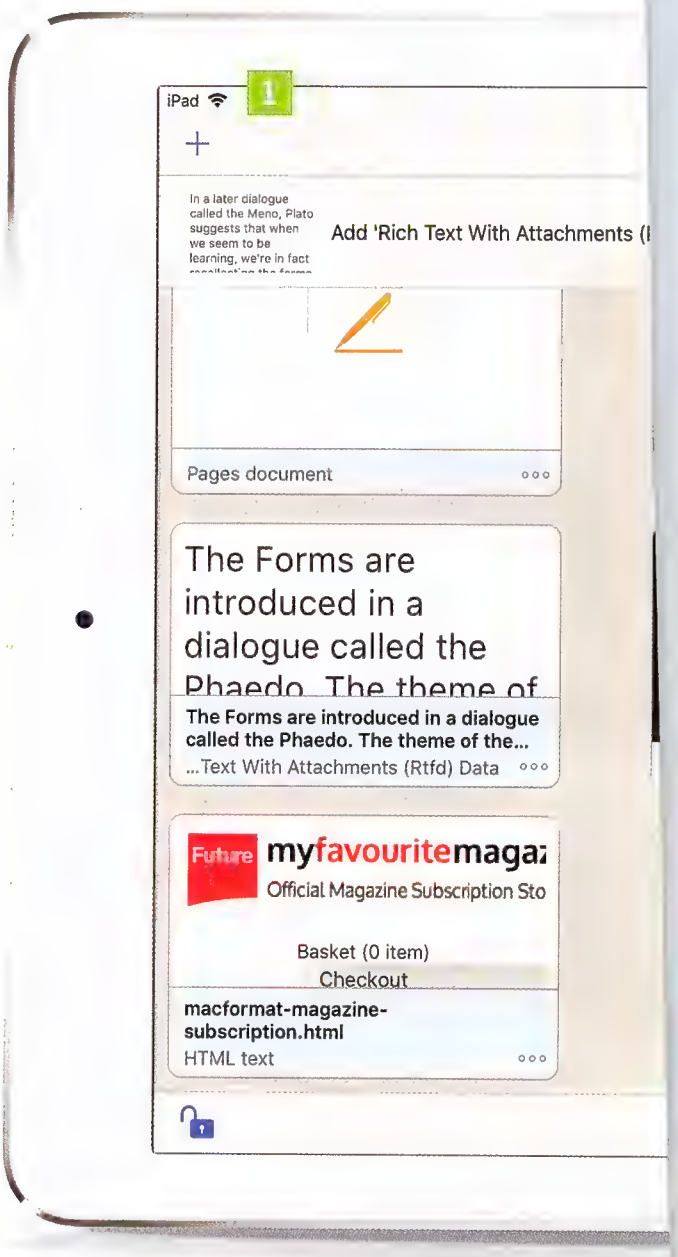


9 TRASH OR UNINSTALL

You can simply trash an item (but make sure you have a backup to restore from just in case). Or to remove all its prefs and other support files too, use an uninstaller such as AppCleaner (free, **freemacsoft.net/appcleaner**).

Improve iOS 11's drag 'n' drop feature

Tim Hardwick shows how to use Yoink as a temporary 'parking space' for files and other items in iOS 11.


iPad
1
In a later dialogue called the Meno, Plato suggests that when we seem to be learning, we're in fact
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The Forms are introduced in a dialogue called the Phaedo. The theme of the...
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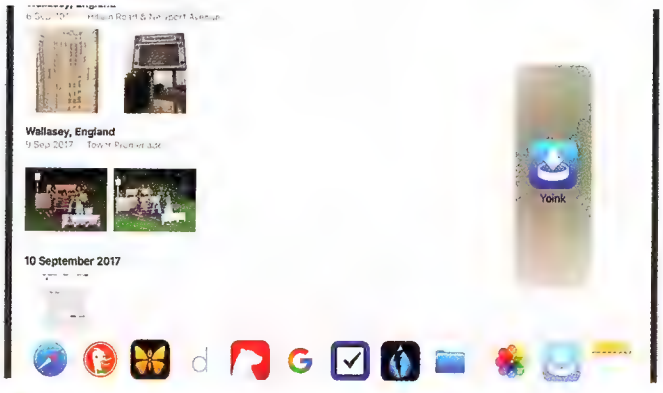
Checkout
macformat-magazine-subscription.html
HTML text

Yoink began life as a desktop utility, and quickly gained cult status among veteran Mac users. The idea behind the app is simple: Yoink acts as a temporary virtual shelf or 'parking space' for items that you want to drag and drop between locations, sort of like a universal clipboard for your digital content. In other words, it makes life easier on your fingers, letting you navigate more comfortably to the destination of an item you're moving.

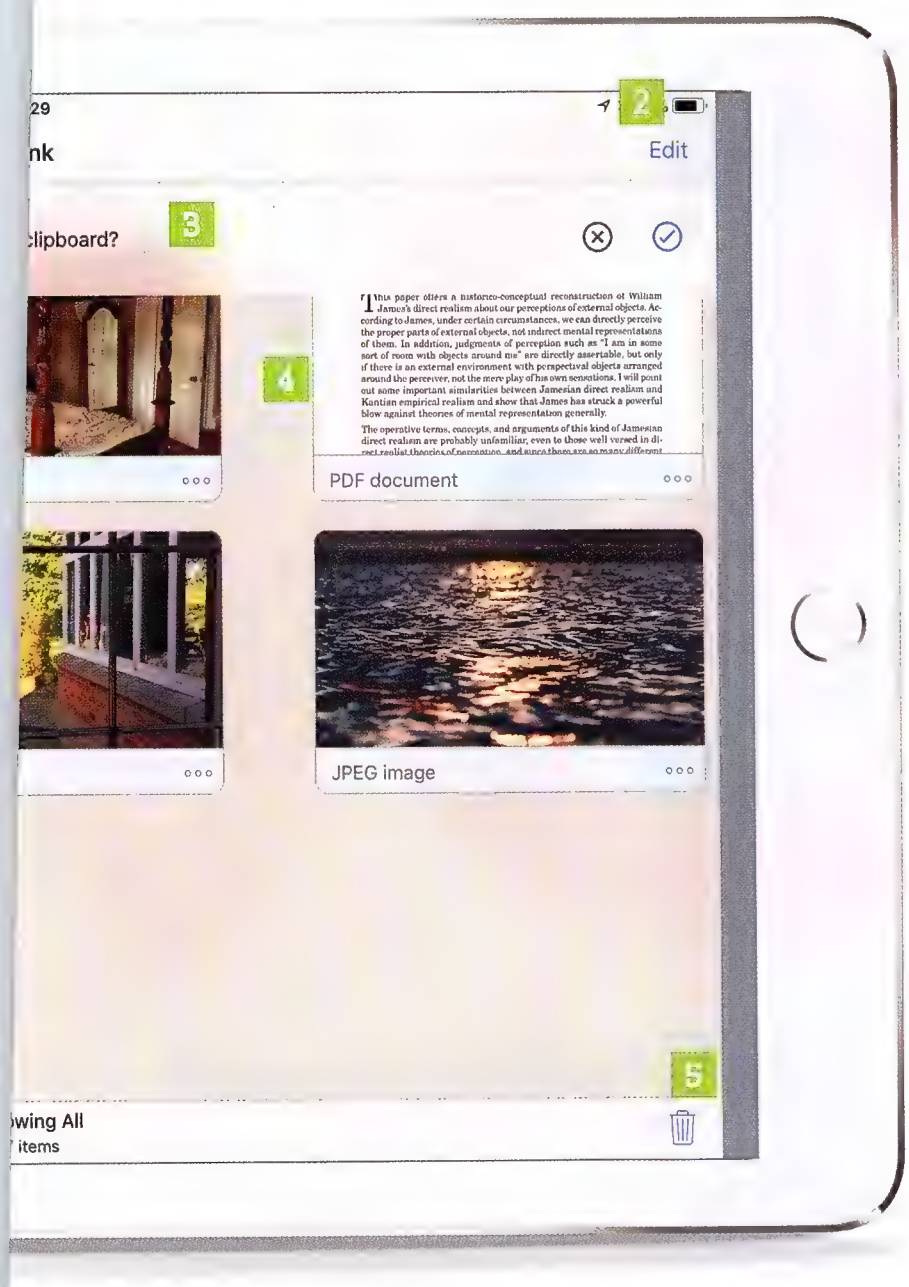
Yoink's popularity on Mac meant it was only a matter of time before it made the jump to iOS, and fortunately, the basic premise of Yoink on iPhone and iPad ($4.49) remains the same. In this short tutorial, we'll guide you through the functionality of Yoink for iOS and show you how to make the most of the app to store your files and snippets, which should free up your fingers for more important things.

Drag and drop with ease on your iPad



1 YOINK IN SLIDE OVER
Use Slide Over to display Yoink as a floating panel. With Yoink installed and another app open, swipe up from the foot of the screen to reveal the Dock; drag Yoink's icon from the Dock on top of the active app, then let go.

2 DRAG ITEMS TO YOINK
Yoink accepts almost anything you can drag, including content from apps, such as images, text snippets, web addresses, emails and documents. Here we're dragging a picture from Photos onto Yoink's temporary shelf.



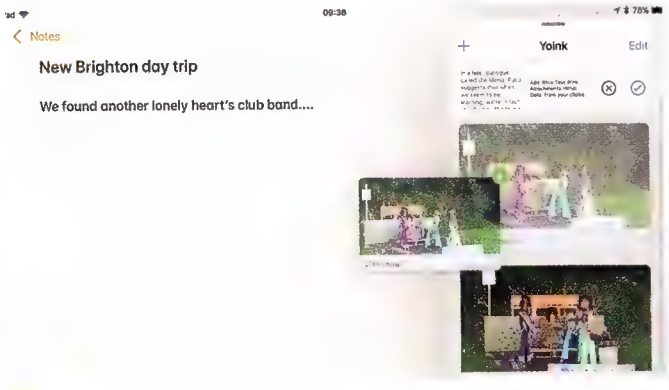
1 ADD ITEMS
Tap the + button to add items to Yoink, whether they're stored in iCloud or on the Clipboard, or to insert a web address.

2 EDIT ITEMS
Tap Edit to give a new title or description to items you've added to Yoink, one by one — or to remove items you no longer need there.

3 SNIPPETS
Yoink recognises when a text snippet or web address is copied to the Clipboard and asks whether to import the item to its shelf.

4 VIRTUAL SHELF
This is where shelved items appear. Tap the three dots beneath an item for more actions you can perform on it, such as sending it elsewhere via iOS's built-in Share sheet.

5 CLEAR THE SHELF
Tap this icon to delete Yoink's contents, or to show any files you've sent to the app's Trash.



3 DRAG THEM OUT AGAIN
Return to the Home screen and open the destination app for your item. If Yoink isn't visible, swipe in from the screen's edge to pull its Slide Over panel back into view, and drag items out from there — photos into Notes, say.

4 MANAGE YOUR SHELF
Our photo remained on Yoink's shelf after we dragged it to Notes. If you'd prefer to move items so they're no longer on the shelf, instead of copy them, tap the padlock (lower-left corner of Yoink) before dragging them out. ■

Dealing with Spectre and Meltdown on Linux

Isolating the world's largest collaborative software project from vulnerabilities is no small task, as a Spectre-haunted Mayank Sharma discovers.

You won't have missed the news about Meltdown and Spectre – two of the most widespread security vulnerabilities that affects millions of CPUs in use today. They were discovered independently by teams at including Google Project Zero and researchers at the Technical University of Graz in Austria, among others.

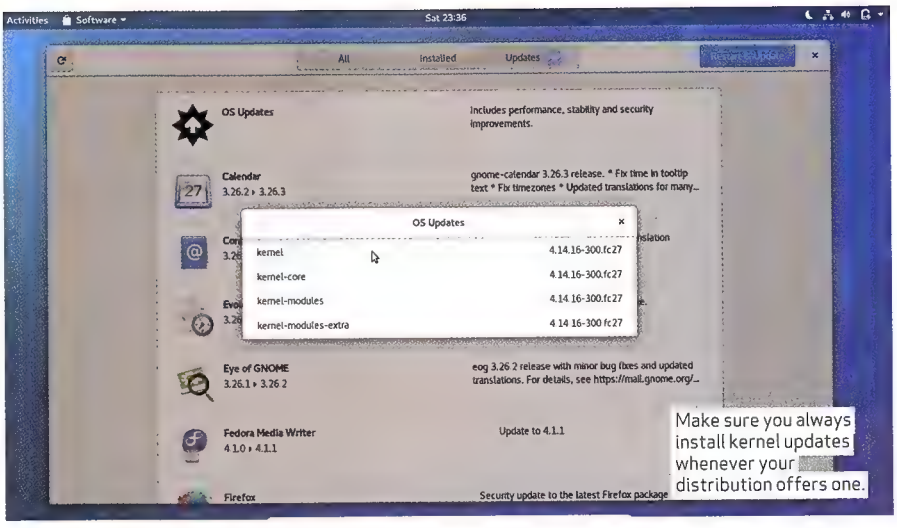
Two things emerged once the dust settled on the implications, extent and severity of the vulnerabilities. One was the loud, unified criticism of how the disclosure about the vulnerabilities was communicated to the software stakeholders. The other was the stellar response by the Linux kernel community to mitigate the damage and contain the threats using software workarounds that compensate for the hardware vulnerability.

With more than 25 million lines of code spread over 61,000 files contributed by over 4,300 developers, the Linux kernel is the world's largest collaborative software project. The agility shown by the behemoth software in fixing a hardware flaw is commendable and deserves a closer look. Much like the kernel development itself, the process of insulating the kernel against vulnerabilities involves dozens of people spread all over the world. A core team of kernel developers form the Linux kernel security team that helps build a software moat around the kernel. They coordinate their efforts with those of several kernel security teams at the various marquee distribution projects that pitch in to test the patches before a vulnerability is made public. The process from the discovery of a vulnerability to patching the kernel with a fix happens at pace.

While the Meltdown and Spectre vulnerabilities and their handling by everyone involved will be dissected at length, it gives us the perfect opportunity to take a peek behind the process and understand the efforts involved before the event notifier spits out the notice about a new kernel update.

Current Linux maintainer Greg Kroah-Hartman recently blogged about how the kernel team handles security threats. Greg notes that the Linux kernel community almost never declares specific changes as "security fixes". He explains that this is because of the difficulty in determining if a bugfix is a security fix or not, at the time of creation. Many bug fixes are only determined to be security related after much time has passed.

When security problems are reported to the kernel community, they're fixed as soon as possible (usually in about a week) and pushed out publicly to the development tree and the stable releases. Greg reasons that this is done to enable affected parties to update their systems before the reporter of the problem announces it.



Make sure you always install kernel updates whenever your distribution offers one.

LIFECYCLE OF A VULNERABILITY

Software projects usually track the list of common vulnerabilities and exposures (CVEs) to identify and fix vulnerabilities in software (see the CVE box, below).

"Every working day, an Ubuntu security team member triages newly assigned CVEs. We scan MITRE's database, the oss-security mailing list, CVE lists maintained by other distros – including Debian, and the source repositories for many open-source projects to identify newly assigned public CVEs," says Emily Ratliff, Head of Security at Canonical. The Security Team examines each CVE to determine whether Ubuntu is affected: "Each CVE is checked into our CVE database.

Eben Upton blogged in detail (**bit.ly/pi-not-vulnerable**) about the Raspberry Pi's invulnerability to Meltdown and Spectre.

Every working day, several Ubuntu Security Team members check the open issues in the database and prepare updates for release."

CVEs aren't the usual starting point for fixing security issues at Fedora. In fact, Justin Forbes, one of Fedora's kernel maintainers, says that the two aren't even tied together: "Many CVEs are requested long after a fix has gone into mainline, or even many distro kernels." Justin reveals that the majority of them are not huge in themselves and of little consequence on their own, but "they still need to be fixed, as people can chain exploits to get much more with many small attacks."

PATCH 'EM UP

According to Justin, a potential security bug is usually found during a code review, or fuzz testing (a quality-assurance technique): "That bug is either fixed with a patch and then someone asks for a CVE, or the finder reports the bug (hopefully to the correct people) and someone ends up requesting a CVE and someone writes a patch to fix it." Justin adds that another frequent case is when a patch is written to fix a bug, and someone notices that the bug was actually a possible exploitable security issue. Discussions around fixing these issues happens in the public, he shares, usually across a combination of relevant upstream lists and security-focused lists.

Besides the vulnerabilities that comes up during code reviews, Justin points out that the kernel and the distributions also have to deal with issues for which a researcher has probably written proof-of-concept code and shown that they are easily exploitable, or can create large problems if exploited. He adds that these issues are frequently sent to various distribution security teams, or to specifically non-public email lists such as security@kernel.org.

Emily explains the process in more detail. She says that security researchers often disclose vulnerabilities to the Ubuntu Security Team privately via GPG encrypted email. When the vulnerabilities apply to open-source projects, an Ubuntu Security Team member will coordinate with the researcher and the upstream communities to report the vulnerability to the project's developers.

"For vulnerabilities in projects originated or maintained by Canonical, the Ubuntu Security Team will file a private security bug in Launchpad and work with internal developers to get the vulnerability fixed," she says, adding that, "Canonical is the CNA (CVE

What is a CVE?

CVE stands for Common Vulnerabilities and Exposures. It was brought to life in 1999 by MITRE, a non-profit organisation that operates research and development centres sponsored by the US Federal Government. The purpose of CVE is to identify and catalogue vulnerabilities in software or firmware inside a database in a bid for companies to improve their security. In other words, the aim of the CVE database is to standardise the way each known vulnerability or exposure is identified. Each entry in the CVE database contains the standard identifier number along with a status indicator, a brief description and references to related vulnerability reports and advisories. The CVE database lists only publicly known vulnerabilities and exposures.

Organisations that identify and hand out CVE IDs for inclusion in first-time public announcements of new vulnerabilities are known as CVE Numbering Authorities or CNAs for short. Canonical, Red Hat and Mozilla are part of the 60-odd companies that have been designated as CNAs.

Numbering Authority) for projects initiated by Canonical developers, so in this case, Canonical will assign a CVE to the vulnerability and notify MITRE of the details of the vulnerability."

Many issues are discussed privately before being made public. Emily points out that the details of these issues are embargoed until an agreed upon Coordinated Release Date. There are many different ways that distributions and other affected parties come together to discuss these private issues. According to Emily, large projects maintain their own lists of security teams who will be affected by security issues in the project. "One such list is the security@kernel.org mailing list, which discusses security issues in the Linux kernel," she says. "OpenWall maintains the distros list (**oss-security.openwall.org/wiki/mailing-lists/distros**), which is frequently used to discuss embargoed issues in a wide variety of open-source packages."

Justin points out that when an issue is posted to security@kernel.org, coordination happens to get the patch developed and tested before such an issue is publicly disclosed: "The goal is to have fixes to users either before or immediately after disclosure to limit the exposure that users have. And of course, as a Linux distribution, the real goal is to have upstream fixed."

KERNEL PLUMBING

Once a vulnerability is found and reported, then the fix is generated in a similar manner to any other bug fix. Emily says that sometimes the reporter may include a patch or a test case reproducing the issue. The maintainers may accept the patch or produce their own fix. In some cases, she adds the distros produce patches and contribute the fixes back to the upstream projects.

Talking from the point of view of a distribution kernel, Justin says that their goal is to ensure that the users have as little security exposure as possible: "Because Fedora is so fast moving, we end up closing a lot of CVEs with 'we fixed that two weeks ago with kernel version x.y.z.'" He suggests that this is because a lot of these issues move through the upstream kernel before anyone requests a CVE or ties them in as security issues.

"For other issues, we'll often find a patch floating around which just hasn't made it into an upstream release yet," he adds. These patches are then pulled in and pushed out to users in the next kernel build. Justin reveals that the Fedora project pushes kernel updates almost every week. More serious issues are handled with a special build specifically to get the fixes out. However, he says that a lot of the CVEs are only questionably a security risk, and closer to regular bugs: "Things like a user with physical access to a machine can cause a DoS, or someone using a very uncommon piece of hardware can crash the system, etc. Those can wait for the regular build."

In case a patch for a vulnerability doesn't exist, Justin says that the project then follows up with developers who maintain that particular section of code, or write a fix and send it to them. He reveals that Fedora is very big on 'upstream first', and goes on to say that, "Ideally, we would not be carrying any patches at all, because everything we need is upstream, so you'll never see a security patch sitting in a Fedora tree that hasn't been floated upstream. In the event of embargoed issues, we might test fixes internally, but they hit the Fedora tree at the time of public disclosure."

Marcus Meissner who is part of OpenSUSE's Security Team, sums up the entire process. "For embargoed issues, most of them happen via the distros and linux-distros' closed vendor coordination lists, where usually patches get posted as heads up and an embargoed date is agreed upon, with only some technical discussion. We also receive embargoed reports directly from some projects, like XEN, CURL and some others, usually accompanied with patches."

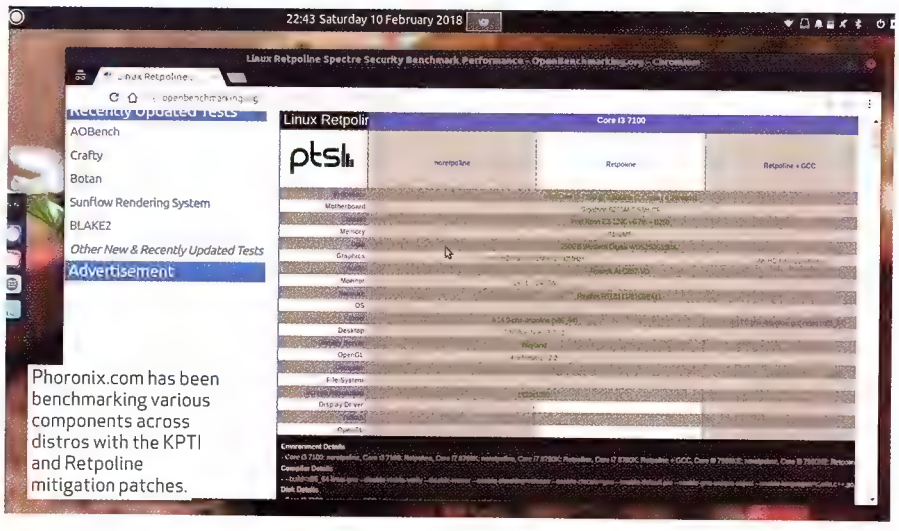
THE TWILIGHT ZONE

Perhaps the most widespread security issues in recent times are CVE-2017-5754, CVE-2017-5753 and CVE-2017-5715 – dubbed Meltdown and Spectre. By most estimates the issues affect all computers built in the past decade irrespective of the operating system they run. The three different threats are not exactly the same, but they're related and use a similar exploit mechanism to gain access to privileged data. In a snap, the vulnerabilities involve reading memory locations that are supposed to be protected and reserved for use by the kernel. They exploit an architectural technique known as speculative execution, which was designed to improve computer performance.

Once the vulnerabilities were uncovered, all the stakeholders including the hardware vendors and the operating systems including several Linux distributions agreed upon 9 January, 2018, as the coordinated release date to disclose the vulnerability. On that date, they would all release updates to mitigate the issues. Due to several circumstances however, the issues were disclosed to the public ahead of schedule on 3 January, 2018. As a result, patches weren't available for some distributions when the vulnerabilities were disclosed.

Work on addressing the vulnerabilities started appearing in the Linux kernel at the end of October with the KAISER set of patches. The KAISER patchset separates the page tables, which are currently shared between user and kernel space, into two sets of tables – one for each side. Subsequently, this work was renamed as kernel page-table isolation or KPTI. The patches were a fundamental change of the kernel's memory management function. Typically, such a major change would have been actively debated and discussed. But since it was fast-tracked through the kernel releases, many people suspected that the work was being done under an embargo.

In a couple of days after the disclosure, all the fixes for Meltdown on the x86 hardware had been backported to the latest stable v4.14 kernel as well as in the v4.4 and v4.9 LTS kernel trees. Linus Torvalds released the first new Linux kernel of 2018, v4.15, on 28 January, after the longest development cycle for a new Linux kernel in seven years with nine release candidates.



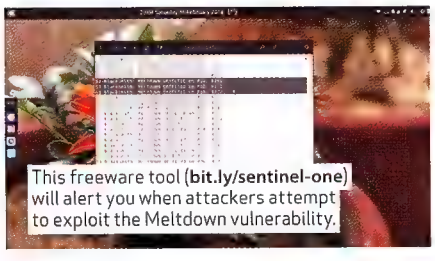
Phoronix.com has been benchmarking various components across distros with the KPTI and Retpoline mitigation patches.

Justin mentions that the Fedora developers knew that Meltdown was the most serious risk as it was fairly simple to exploit: "We were working with the KPTI patches over holidays to ensure that we were set to push fixes as soon as disclosure happened, and I think we got those out within a few hours of disclosure." He goes on to admit that there is still some follow-up work with other architectures, but assures us that those are being fixed as quickly as possible, and have less exposure.

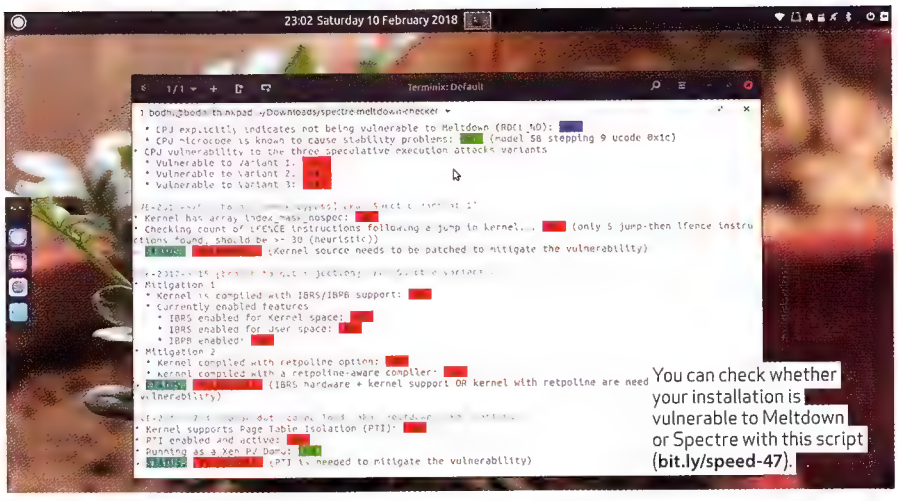
It was pretty much the same story over at Canonical. According to a blog post, Canonical was made aware of the vulnerabilities under embargo in November 2017 and their engineers were working "through the Christmas and New Years holidays, testing and integrating an incredibly complex patch set into a broad set of Ubuntu kernels and CPU architectures."

Of the two, Spectre is the trickier one and, as Greg writes in a blog post, was the last to be addressed by the kernel developers: "All of us were working on the Meltdown issue, and we had no real information on exactly what the Spectre problem was at all, and what patches were floating around were in even worse shape than what have been publicly posted." The Spectre issue is addressed in kernel v4.15 with the Retpoline code that was originally developed by Google.

Justin agrees that, although Spectre is much more difficult to exploit, it is still critically important to fix:



This freeware tool (**bit.ly/sentinel-one**) will alert you when attackers attempt to exploit the Meltdown vulnerability.



You can check whether your installation is vulnerable to Meltdown or Spectre with this script (**bit.ly/speed-47**).

"We followed upstream on this [Spectre], sometimes doing several builds a day to test new revisions of those patches. Again, x86_64 was the top priority because that is where the most users are."

Laura Abbott, another Fedora kernel security engineer adds that, since Fedora stays so close to upstream, they were able to mostly take the patches as posted and just apply them to the Fedora kernel: "Distributions which were on older kernels had to do much more work to backport to their kernels."

LINES OF COMMUNICATION

In terms of communication, Marcus explains that for deeper and longer running technical issues like with Meltdown and Spectre, ad-hoc communication channels / lists are established. For example, for Meltdown a special external mailing list had been set up, where the involved kernel developers were subscribed. Here, they discussed integrating the mitigations and reviewed backports.

There has been a fair amount of quibbling about how this process has played out (see boxout, below) and Linus Torvalds has been very vocal – as usual – in his criticism of Intel and its approach to the entire episode. Justin isn't impressed, as well: "Clearly, the whole thing has been a bit of a mess, and I hope that we have learned something so that the next time something like this comes along, we can do a better job of coordinated disclosure."

While the immediate threat has been handled, Justin believes the vulnerabilities will haunt us for quite some time. "I think, due to the nature of these issues being architectural design and not simple code issues, this is something that will be ongoing for a bit."

"Plug the holes as quickly as possible, then optimise the fixes", is the way to move forward says Justin, commenting on the strategy of the kernel developers. Once the dust has settled and everyone's done pointing fingers, it is the community of open-source developers that has once again saved the day. Justin sums it up perfectly: "No matter what distribution you are working with, or product you are manufacturing, the end result is that users need to be protected."

Get off my lawn

There's been a lot of grumbling on the discovery to the communication and fixing. Greg shared his concerns in a blog post: "As for how this was all handled by the companies involved, well this could be described as a textbook example of how NOT to interact with the Linux kernel community properly. The people and companies involved know what happened, and I'm sure it will all come out eventually, but right now we need to focus on fixing the issues involved, and not pointing blame, no matter how much we want to."

Linus Torvalds was annoyed at Intel's attempt to pitch the vulnerability as a feature with an optional flag to disable it. "All of this is pure garbage. Is Intel really planning on making this s**t architectural?" Yet not everyone's happy with the Linux kernel's handling of the situation, either.

Grsecurity's Brad Spengler said, "I think it points to either a massive lack of investment in security on behalf of the billion dollar companies involved in Linux, failure to retain the necessary talent, or a combination of both, that we seem to be the only ones doing this work, let alone without the benefit of months of advance notice in private."

And spare a thought for the *BSD camp, that was left scrambling for a solution. "We have received no non-public information. I've seen posts elsewhere by other *BSD people implying that they receive little or no prior warning, so I have no reason to believe this was specific to OpenBSD and/or our philosophy. Personally, I do find it....amusing?", wrote OpenBSD's Philip Guenther.

Track and recover Linux devices with Prey

Mayank Sharma has a Gollum-esque attachment to his devices and a Nazgûl-like force to rain down vengeance on anyone who takes them.

You don't have to be careless to lose your laptop, but that doesn't mean you should just accept the fact that your machine is gone forever. Prey helps recover your stolen devices by enabling you to track and control them remotely, and make them unusable to anyone who's got them. Prey helps you keep an eye on the perpetrator, and how they're using your machine and collate all kinds of information that will come in handy when you report the theft to the authorities.

Prey installs an agent on your device that runs in the background and periodically sends an HTTP request to check in with its online headquarters whether it should gather information and perform any action, or stay asleep. When you lose a device, you mark it as such on Prey's dashboard and the device then starts collecting data to help you track it down.

Besides Linux, Prey works on several operating systems including Windows, macOS, and even Android and iOS, so you can use it to track laptops and mobile devices as well. You can use it for free to track up to three devices, or upgrade to one of the several paid plans that start from US$5 per month (about $6.50).

The Prey project has pre-compiled binaries for deb-based distros such as Debian and Ubuntu. To set up Prey on these distros, head to the Download section on the project's website (**www.preyproject.com**) and grab either the 32- or 64-bit binary. Then double-click the .deb file to install the Prey agent.

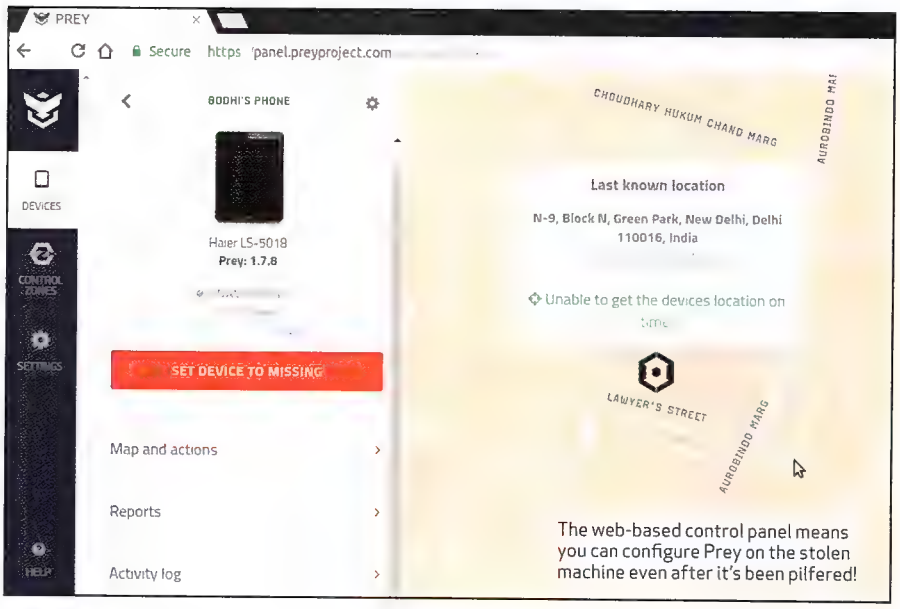
There are a couple of other ways to install Prey. Some distros package Prey in their official or third-party repositories like Arch's AUR. Furthermore, since it's written in Node.js, you can install Prey using the npm package manager. First install Node.js using your distro's package manager (**nodejs.org/en/download/package-manager**) and then type `npm install -g prey` to fetch the Prey client from the npm repository. Remember, however, that unlike the official binary packages, you'll have to manually update this installation with `npm update -g prey` whenever a new version is released.

After the client installs, Prey will fire up its graphical configuration tool. The first time around, you'll have to create a new account by filling in your name, email address and a password. That's all there's to it. In the background, the Prey agent will add this computer to the list of tracked devices. It'll automatically pick up the name of the device and its type, which you can edit later from Prey's control panel. For subsequent installations on other devices, select the option to link the device with your existing account and the device will automatically be tracked.

LAY THE TRAP

After you've set up your device, you can configure its behaviour via Prey's web-based control panel. Head to the project's website and click the Log In button in the top-right corner and authenticate with the email address and password that you specified on first launch.

The control panel is broken into various sections that manage different aspects of the device. By default, the control panel takes you to the Devices section that lists all the added devices. Click a device to view the autocollated information gathered by the Prey agent. The landing page for each device shows you brief information about the device, such as its OS and the version of the Prey client it's running. The gears



The web-based control panel means you can configure Prey on the stolen machine even after it's been pilfered!

icon on the top helps you alter the name of the device or remove it from the list of devices being tracked.

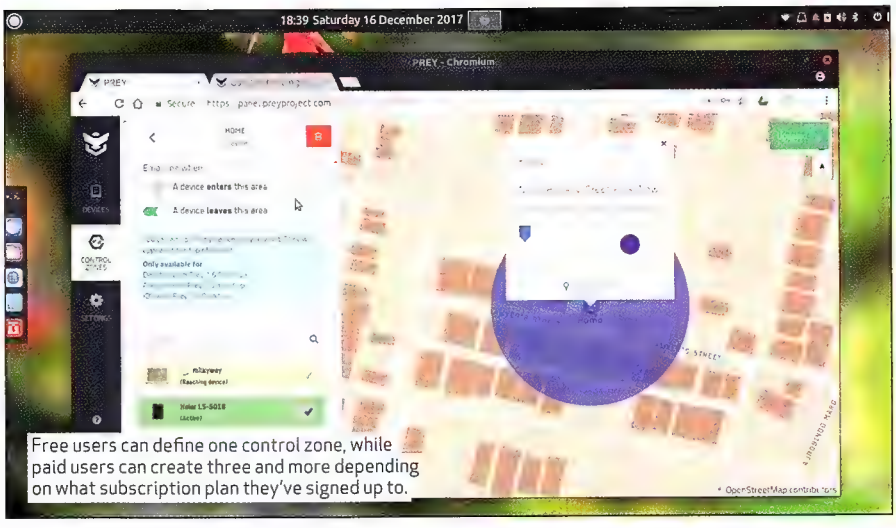
Switch to the Hardware information section for more details about the hardware on the device, such as its serial number, which comes in handy when submitting a detailed report to the authorities. The 'Maps and Action' section displays the device's last-known location along with a button to display its current location by sending a query to the device.

KEEP IT PERSONAL

Prey also has a very useful geofencing feature with which you can mark personalised zones in the map and ask Prey to send you an email whenever one of the devices assigned to a zone leaves or enters the area. Head to the Control Zones tab to define a zone in relation to the current location of a device. After creating the zone, you'll have to mark the devices you wish to add to this zone. By default, Prey will email you whenever a device enters or leaves this zone, but you can disable either of these two actions.

Adjacent to the map is the Actions flap that lists several activities you can perform remotely on the device from the dashboard. Some of these options are designed to help you find your device or perhaps even dissuade the thief if they're in the vicinity. The Alarm option sounds a loud alarm from your missing device to help you locate it, if it's nearby. It lists four different sounds that will be blared out from the speakers on the device for 30 seconds. Then there's the Alert option that displays an alert message on the screen of the missing device. You can use it to send a 250 character-long notification that'll be displayed on the desktop of the device.

If these don't work to discourage the thief, you can use the Lock option to prevent the computer from being used until a password is entered. You can also sound the alarm after locking the device to prevent the perpetrator from muting the speakers. The lock can be turned off remotely as well, and is a good means of irritating the thief when used together with the alarms and notifications.



Free users can define one control zone, while paid users can create three and more depending on what subscription plan they've signed up to.

KEEP TABS ON THE PREY

When you lose the laptop, log in to Prey's web panel, head to the device's page and click the big red button to mark it as missing. Prey can discreetly gather lots of information about the missing device and its current operator.

As soon as the device comes online, Prey will use nearby Wi-Fi access points to interpolate the location on your device. It also gathers other network-related information such as the public IP address of the network the device is connected to. In addition to its location, Prey also takes a screenshot of the desktop. Sooner or later, you'll receive a screenshot of him logging into his account on a webmail or some other website. While you won't get his password, you'll be able to clearly see his unique username, using which you can contact him. If your device has an built-in webcam, Prey will also secretly take snapshots of whoever's facing it. It won't take long before you catch the crook in front of your stolen device.

You can set the interval after which Prey wakes up and collects the required information. The free version gathers up to 10 reports every 10 or 20 minutes, while the paid version can fetch reports every two minutes. Prey emails you the reports on the address you used to register with the service.

You're all set now. As soon as the miscreant goes online with your stolen device, the Prey client will alert the Prey web service. So while we hope you never lose your laptop, in case you do, you're now fully prepared to take on the guy who's got it. Prey equips you with the tool to either force them to return your device or collect enough information to build a strong case for the authorities to take action.

The paid versions offer some additional useful features, particularly remote wipe that helps you delete all kinds of files. For example, if you select Documents, the Prey client will remove the Documents, Downloads, Desktop, Pictures and Videos directories for every user. Similarly, selecting Password will zap the .gnome2/ keyrings and .ssh directories, and Emails will remove all data related to local mail and Thunderbird. Users of the Business edition get some additional features that'll help them track multiple devices, such as customisable labels and advanced search.

Prey on Android

In addition to computers, Prey can also protect Android and iOS mobile devices. To get started, download the app from either the Google Play Store or Apple's App Store. Once it's installed, hook it to your account or create a new one, just like you did on the desktop version of the app.

After associating it with your account, Prey prompts you to activate the device administrator by locking down the software with a password for extra security. Once these measures are activated, whoever's got your device will first have to revoke the privileges provided by the administrator before they can uninstall the software from your phone. The Prey for Android app has the Disable Power Menu option which, when enabled, prevents your device from being turned off by disabling its power menu. You can also set a security PIN and use it to send instructions to your mobile device via text messages.

Furthermore, the Prey dashboard for the Android device has an additional option. Use the Toggle camouflage action that will then hide the icon for the Prey app from the Home screen.

Make your games sharper with extreme antialiasing

Phil Iwaniuk shows how to get the smoothest curves and sharpest edges.

Forget fair microtransaction models and the magic formula for a successful esports game – these are but flash-in-the-pan challenges the games industry currently faces. For a much longer time, 3D designers were stumped by a far more prosaic problem: how to draw curved and diagonal lines without them appearing like a blocky staircase of pixels.

Aliased polygonal edges – or jaggies, as you say in today's parlance, with your low-slung jeans and dangerous, new ideas – were a simple fact of 3D graphics for over a decade. It was only in the mid-2000s that antialiasing (AA) became sophisticated enough to smooth out those lines until they appeared realistic, and it still takes a lot of computational power to do so.

In this smoother-edged age, though, new problems have emerged. What if the antialiasing options baked into your game aren't sufficient? And what about playing old games, which offer only perfunctory antialiasing – is that the end of the line for your crusade against the jaggies?

Well, no. There are lots of other options. Here's how to go beyond the graphics menu's limitations, and antialias those edges so much that even Tom Jones would deem them smooth.

1 GET HOLD OF GEDOSATA

You know what they say – if in doubt, downsample. Don't worry about who 'they' are, just trust us: They're always saying it. Downsampling is essentially supersampling AA (SSAA) by another name: You render a version of the original image that's much, much bigger – usually x2, x4 or x8 times the size of your native resolution – then you downsample that enormous image so it fits back within the dimensions of your monitor. And you do this by downloading Generic Downsampling Tool, aka GeDoSaTo.

The advantage of using this program over the AA options in your game's menus is that you get a double-whammy of fidelity: higher image resolution, and smoother edges by virtue of the former. After all, the more pixels there are creating an image, the harder it is to see that step effect when pixels on diagonal lines display an edge. Plus, there's support for really big resolutions, so if you want to go extreme with your AA, this is the program.

2 CREATE A CUSTOM SUPERSIZED RESOLUTION

Once GeDoSaTo is up and running, simply hit 'Edit Settings' to navigate to the pictured text file **[Image A]**. Here, you'll see two sets of resolutions: the larger supersampled resolutions above, and your monitor's native resolution below. Edit these figures to taste – usually going for 1.5 times your native resolution, then two times, then 2.5, then something more ambitious, such as four times, is the best approach. If all works as planned, your game will suddenly recognise these new resolutions, and offer them in the display options menu. We recommend those sizes in particular because rendering images at enormous resolutions, then squishing them back down to size, takes a lot of your GPU's resources, and you'll want a few settings to switch between later on when you're tweaking for optimal performance. The laws of diminishing returns definitely apply here, too, so you may find that 2x downsampling produces a sufficiently smooth image.

3 TURN OFF AA IN-GAME

Now, with GeDoSaTo still running in the background, select one of the higher resolutions that have just magically appeared in your game's graphics options menu or launcher. Next, remove any AA effects in the game **[Image B]**, and observe whether downsampling alone has smoothed out the jaggies. There's no point sending two fire trucks out to the same fire, after all. Unless it's a big fire. (We're not totally clear on how the fire brigade works.) If you're getting great antialiasing but a low frame rate, try a smaller resolution. If you're getting the opposite, enlarge the resolution that GeDoSaTo creates.

4 LAYER AA WITH NVIDIA INSPECTOR

Here's another approach to your extreme AA solution: layer different techniques. Like downsampling, it's a resource-heavy pursuit, but what about the word 'extreme' implies low power consumption? Pro tip: This is

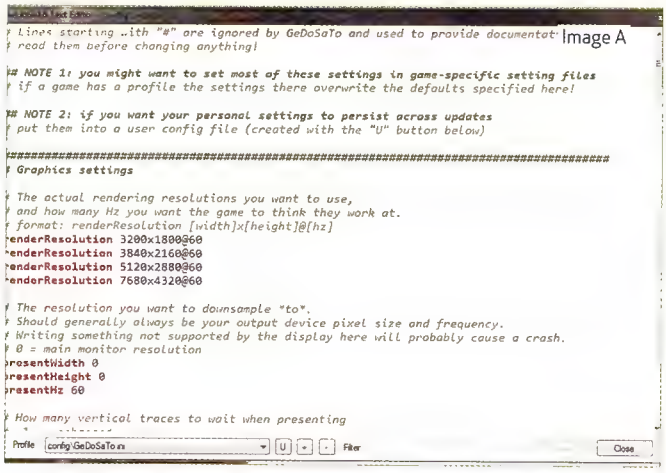
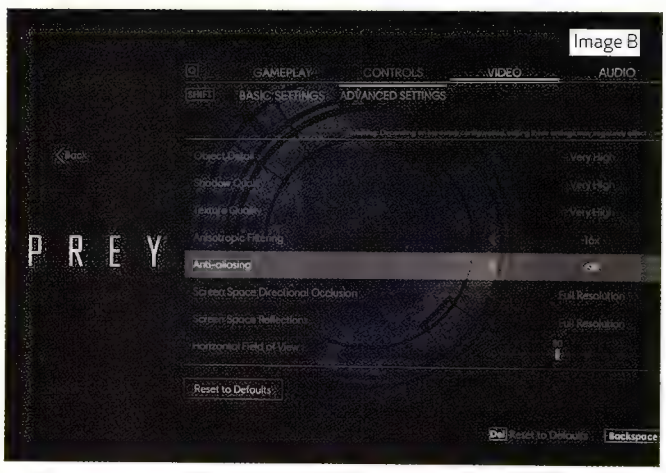


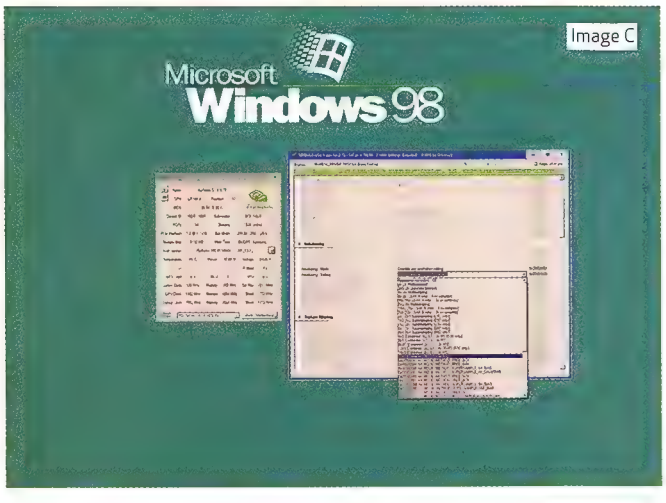
Image A
Lines starting with "#" are ignored by GeDoSaTo and used to provide documentation
read them before changing anything!
NOTE 1: you might want to set most of these settings in game-specific setting files
if a game has a profile the settings there overwrite the defaults specified here!
NOTE 2: if you want your personal settings to persist across updates
put them into a user config file (created with the "U" button below)
Graphics settings
The actual rendering resolutions you want to use,
and how many Hz you want the game to think they work at.
format: renderResolution [width]x[height]@[hz]
renderResolution 3200x1800@60
renderResolution 3840x2160@60
renderResolution 5120x2880@60
renderResolution 7680x4320@60
The resolution you want to downsample "to".
Should generally always be your output device pixel size and frequency.
Writing something not supported by the display here will probably cause a crash.
0 = main monitor resolution
presentWidth 0
presentHeight 0
presentHz 60
How many vertical traces to wait when presenting
Profile
config\GeDoSaTo.ini
Filter
Close



especially handy for older games with weaksauce AA options. Download and install Nvidia Inspector to begin this layering process. Hit that tiny green icon next to the 'Driver Version' readout and you'll see a voluminous options menu pop up. First, head down to the 'Antialiasing—Mode' drop-down menu and select 'Override any application setting'. We'll be using two AA techniques in tandem within Nvidia Inspector, so we don't need to triple-dip by using the game's AA, too. Next, navigate to 'Antialiasing—Setting' and choose '32xS [2x2 SS + 8x MS]' **[Image C]**. That'll apply two different antialiasing techniques — supersampling and multisampling — taking a total of 32 samples of each frame. While the former creates an artificially higher resolution render of each frame, multisampling AA takes color samples from different points within each pixel, so it can get a better idea of the bigger picture, and smooth lines out accordingly. That is extreme antialiasing, friend.

FINAL TWEAKS

We're going even deeper here, so first check you're still getting a playable frame rate with the AA setting we just enabled. Good? Good. Now we're tackling alpha textures — things such as chain link fences, grass and foliage — that traditional AA techniques can struggle to smooth. Or, if they're too aggressive, they can blur them out so much that they become invisible. Back in Nvidia Inspector, you'll find a setting just below the AA setting from Step 4 called 'Antialiasing—Transparency Supersampling'. Select '8x Sparse Grid Supersampling' from the drop-down menu. Now you'll have an AA solution that applies two techniques to every frame, and another one looking out for alpha textures. And best of all, it's all happening independently of your game's graphics options menu, so you can apply it to whatever you play **[Image D]**.



Going too far

It runs contrary to the spirit of this guide to say so, but there is such a thing as too much antialiasing. And it's not just defined by the point when your frame rate renders the game unplayable. Over-aggressive AA can blur out images, make entire textures disappear, and give an uncanny valley effect to old games. *Doom* was never intended for smooth edges and high-res textures, so when modern AA techniques are applied, the result is only a passing resemblance to the game you remember. Similarly, in 2D games that feature line drawings heavily in their art style, the once-crisp lines get extra pixels, intended to smooth them out, but which make it look as though someone's spilled a bottle of water all over your game. So use AA sparingly in 2D and early 3D titles.

Mastering the master

A full-tower Coffee Lake machine meets way too much money in this month's PC build.

THE CONCEPT

Long before this journalist started working for *APC*, he was but a meager enthusiast, a humble bumbling varsity student, fawning over expensive hardware, and meticulously planning hypothetical builds at all sorts of budgets and specifications. Outside of the aesthetically pleasing BitFenix Prodigy and Corsair's Obsidian lineup of cases, the chassis that attracted the most attention originated from the legendary manufacturer Cooler Master, with its Cosmos II being first and foremost in the list of "awesome stuff I'd like to build in". Tech journalists around the globe waxed lyrical about its brilliance, with its sturdy frame and intuitive design helping retain its glory since conception.

When we first witnessed the beauty of the Cosmos II's new sibling, the C700P, the desire to build in it was overwhelming. The plan was to create something a little less restrained than we typically do, in part because, hell, it's a Cosmos, and secondly because the market is, well, what it is. The cost of GPUs and memory right now has catapulted standard builds into the heady heights of 'dream machine' prices — but without the performance. It saddens us to have to say this but, unfortunately, for the time being, that's just the way it is, at least until Samsung and co get their proverbial crap together. That said, try to imagine it's a reasonable build, that parts are priced fairly, that there isn't a hardware shortage, and that everything is right in the world.

So we've built a rig that showcases the height of Coffee Lake's prowess, with no expense spared on motherboard, memory, processor or case.

WHEN LIFE GIVES YOU LEMONS...

Spend way too much money on a motherboard and call it a day? That's our philosophy for this build. Damn, that mobo is pricey, but not without good reason. We wanted to go with Coffee Lake for this rig on a number of grounds. Six cores and 12 threads is enough to take care of any application we can throw at it. Whether it's rendering, streaming, gaming or two of those at once, this machine is more than capable of outputting a significant amount of content, quickly and efficiently. On top of that, Coffee Lake has proved that Intel still dominates the field when it comes to single-core performance, and because games typically rely more on clock speed than on multiple cores, Intel is also still the chip of choice for most AAA titles.

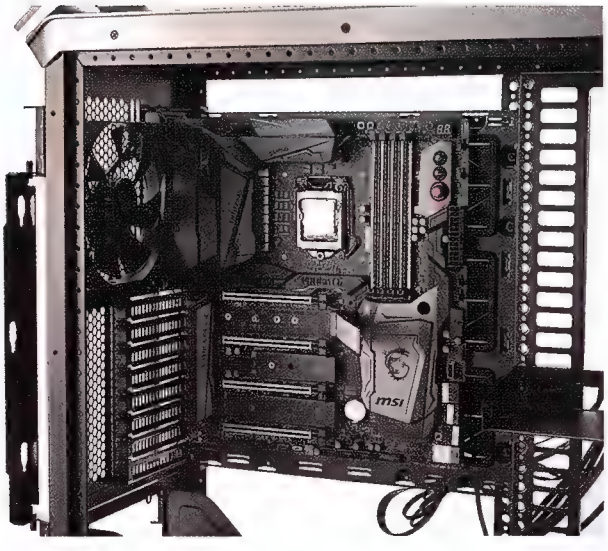
Couple that with a motherboard that goes above and beyond when it comes to connectivity and quality audio, and we're on to a winning combo. The Godlike supports up to five M.2 PCIe SSDs, a sixth via U.2, plus six SATA drives for storage alone. On top of that, it packs in four separate PCIe x16 slots, triple Gigabit Ethernet, and wireless A/C. MSI has crammed practically everything on to this lumpy chunk of PCB, and, to be frank, it looks sweet.

We decided to go with some serious storage for this build, with less emphasis on solid state for once — sorta. We're talking a 512GB Intel 760p PCIe SSD for the boot drive, with a stellar 12TB of spinning platters from Seagate's BarraCuda Pro HDD. For our GPU powerhouse, we've gone with our ever faithful stock GeForce GTX 1080 Ti — a no-frills card, and that's all there is to it. Job done.

PARTS LIST

PART		STREET PRICE
CASE	COOLER MASTER COSMOS C700P	$399
MOTHERBOARD	MSI Z370 GODLIKE GAMING E-ATX	$799
CPU	INTEL CORE I7-8700K	$520
MEMORY	32GB (4X 8GB) CORSAIR DOMINATOR PLATINUM 3,200MT/S	$740
GPU	NVIDIA GEFORCE GTX 1080 TI	$1,199
PSU	COOLER MASTER V650 80+ GOLD	$169
STORAGE 1	512GB INTEL 760P M.2 PCIE SSD	$329
STORAGE 2	12TB SEAGATE BARRACUDA PRO 7,200RPM	$750
COOLING	COOLER MASTER MASTERLIQUID ML240L RGB	$99
OS	WINDOWS 10 HOME	$135
TOTAL		$5,139

"Imagine it's a reasonable build, that parts are fairly priced, that there isn't a hardware shortage..."

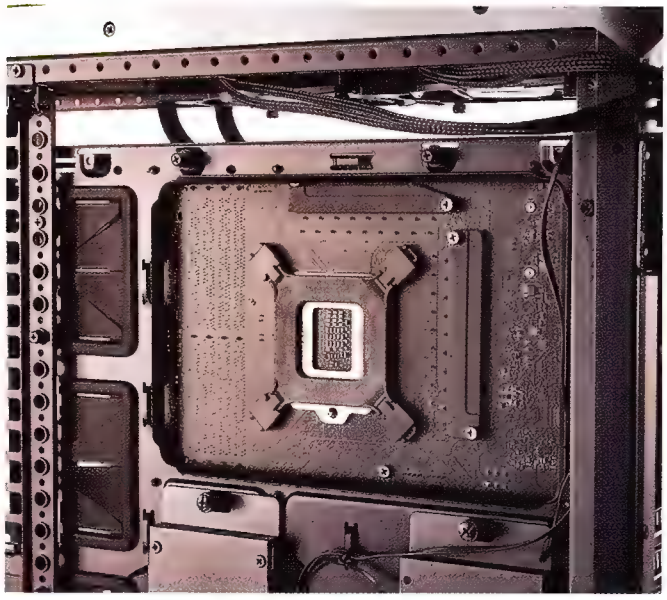


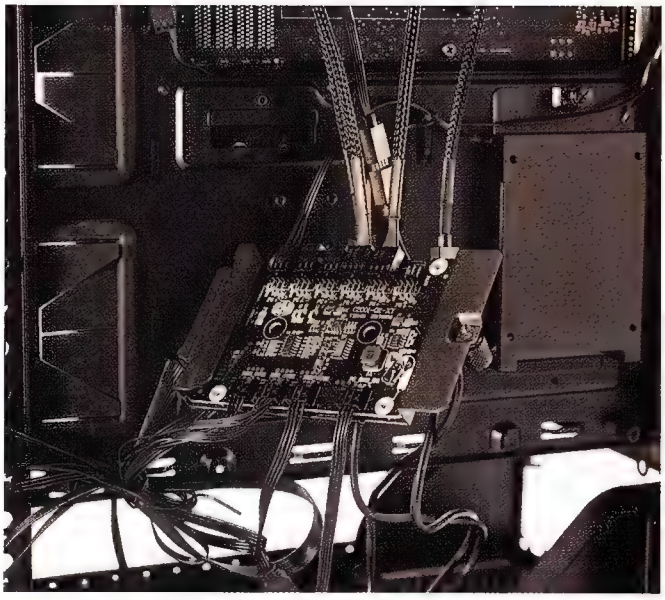
1 MOTHERBOARD INSTALLATION

The Godlike Gaming is a monstrous motherboard of Coffee Lake destruction. And it fits in the Cosmos C700P like a dream. It's big, seriously big — E-ATX to be precise, which is fairly impressive for a mainstream platform, but the audio componentry, combined with the extensive overclocking hardware and ridiculously over-the-top I/O, makes it more than worthwhile. Word of note: The Cosmos C700P doesn't have all the stand-offs installed for ATX by default, so you do have to pop those in yourself, using Cooler Master's included stand-off mounting tool.

2 COOLING CHOICES

We had a long chat with Cooler Master about what kind of cooling we should use for this build, and it was a toss-up between these two little beauties: On the left is the ML240L RGB all-in-one; the one on the right is the Master Air MA610P with RGB controller (think of it as a slightly more premium variant of the Hyper 212 Evo). Both are swanky, but with concerns over the Core i7-8700K being perhaps a little too hot-headed when clocked any higher than stock, we opted for the AIO. That said, another air-cooled build is definitely on the cards soon, because they look so good when done right.





3 BACKPLATE PERFORMANCE

Amazingly, Cooler Master hasn't fallen into Asetek's patent trap, and has its own bespoke mounting solution. It's fairly intuitive, although you do need to use the instruction manual to get a grip on which bolt goes where. It's also worth noting that you'll need a third hand to hold everything down while you try to secure it in place on the other side of the board.

4 FAN DOMINATION

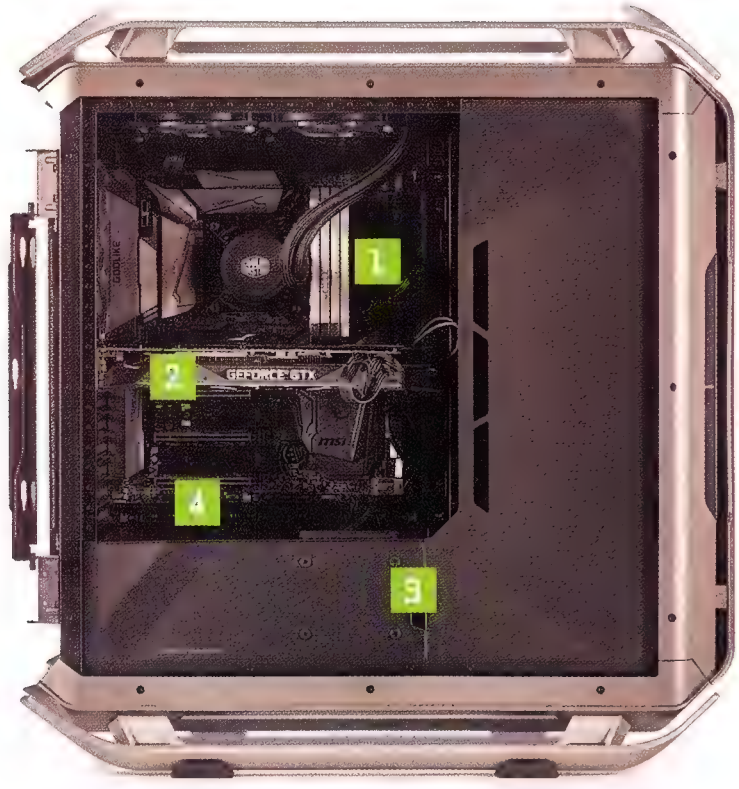
One of the biggest surprises in the Cosmos C700P was this little beauty, carefully hidden away under the SSD mount at the back. It's a beastly chunk of PCB, capable of powering up to 10 PWM fans and three RGB strips. It's controlled by a switch on top of the chassis, or via a link up to your motherboard. Two things to note: If you want to install an SSD here as well, don't panic, because there are pre-threaded holes going through to the other side, so you can still secure it down, no problem. Secondly, don't forget to plug in the SATA power that's sneakily hidden in the bottom of this monstrous thing.

5 ALL THE STORAGE

For this build, we've opted to go with a single 12TB BarraCuda Pro drive from Seagate. It may not have the same prestigious performance as its IronWolf twin we've reviewed this issue (see page 26), but it's still no slouch, and more than enough storage for any form of media we want to throw its way. Ideally, we'd have preferred to perhaps have four 3TB drives instead in RAID 1, and do away with the additional 6TB for the sake of redundancy, but Seagate was cruel, and sent us this instead.

6 PSU REQUIREMENTS

Yep, for the sharp-eyed among you, you can possibly make out the 650W power supply handling all that heat-inducing hardware. Amazingly, even under full load, we don't expect to see this machine hit anything more than 520W, giving us well over 130W of headroom to play with. It's likely we won't be tweaking this build much, so this small saving is more than adequate. Incredibly, even with 4 x 8GB sticks of DDR4, a GTX 1080 Ti, and Intel's most power-hungry consumer processor yet, on a 650W PSU, we're still stuck merrily at 80% of overall capacity, which is the exact sweet spot needed for maximum efficiency.



1 32GB of Dominator Platinum @ 3,200MT/s is probably a touch overkill for this build, but there's no denying it looks awesome.

2 Our GeForce GTX 1080 Ti has only very subtle red lighting in the actual fan blades, meaning a very clean-looking silver GeForce logo to complement the build.

3 These two panels can be easily removed with just a couple of Phillips head screws, to allow for easy installation of 3.5-inch hard drives and the PSU.

4 If pricing was less of an issue, a second GTX 1080 Ti and a sleek SLI bridge would have made this machine killer — although a bigger PSU would then have been a must.

Cosmic entity

Now that's all over, how was building in the Cosmos's successor? Pretty sweet. It's one of the few cases that you can strip down almost completely to its bare bones. There was very little left of it on our usual skeleton run, and it made building in the colossus far easier than we first thought. The ATX stand-offs requiring pre-installation did catch us a little off-guard — after all, who in their right mind would plop an ITX motherboard in a full tower? But that aside, we had very little trouble with it.

One thing we would add is that it's quite tricky to tinker with after you've built it. Removing those front side PSU and hard drive bay covers makes system installation easy, but trying to sort things out after they were reinstalled was a bit of a nightmare. In short, we couldn't quite identify how that RGB fan controller was powered at first, deducing it to be some sort of sorcery and internal headered USB magic. It was only under further inspection, once the system was complete, that we noticed the not-so-obvious SATA power located at the bottom of the fan controller. At which point, we immediately threw an additional SATA power cable into the PSU, which was frustrating to say the least.

Still, we finally got it plugged in, with those LED strips firing away in a stunning shade of purple. It's a shame that you guys don't get to see the fun we have at the photo studio. Most of the final shots (especially with LEDs) are comprised of two images: one that's well lit, and an LED shot taken in pitch black. The two shots are then skillfully stitched together so everything is lit to the degree that our eyes typically see. In complete darkness, those light bars really do shine, and it's beautiful.

Performance was a given. With the Core i7-8700K pumping away at this rig's heart, it's a masterfully crafted single-core killing machine. Multiply that by 12, and you're looking at some very tasty rendering performance. There's little that this system can't do, especially in game. There are a few things we'd like to tweak, though, to make that price point more bearable. For instance, a bigger PSU and a braided cable kit would be stellar. Couple that with some additional off-the-shelf cooling and internal lighting, and it would really round out the build. Also, some method of reducing that GPU sag would be good.

All in all, our Cosmos was a joy to build in, and stood up to its predecessor's legacy. Whether it will also stand the test of time, though, we'll have to wait and see. ■

BENCHMARK RESULTS

	APC LABS TEST PC	THIS SYSTEM
CINEBENCH R15 MULTI (INDEX)	2,178	1,390 (-36%)
CRYSTALDISK QD32 SEQUENTIAL READ (MB/S)	3,136	3,065 (-2%)
CRYSTALDISK QD32 SEQUENTIAL WRITE (MB/S)	2,126	1,580 (-26%)
RISE OF THE TOMB RAIDER (AVG FPS)	68	64 (-6%)
TOTAL WAR: WARHAMMER II (AVG FPS)	42	42 (0%)
TOM CLANCY'S GHOST RECON WILDLANDS (AVG FPS)	38	38 (0%)
3DMARK: FIRE STRIKE (INDEX)	6,988	6,939 (-1%)

Our *APC* Labs Test PC consists of an Intel Core i9-7900X, 32GB G.Skill Ripjaws V Series DDR4 @ 3,000, MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro PCIe SSD. All tests performed at 4K at the highest graphical profile.

Feed your plants with a Raspberry Pi

A case of green fingers is nothing to worry about, as Kent Elchuk gives you the goods to monitor a garden with images, video and a moisture sensor.

This month's tutorial will be a guide to growing healthy, hydroponic (or organic hydroponic) food with the aid of a Raspberry Pi. Hydroponics has many advantages compared to other, more conventional methods of food harvesting, including faster rates of growth and improved water conservation.

Because plants take up their 17 essential nutrients in liquid form, going down the hydroponics route enables gardeners to apply a precise diet to their crop, while using a sterile medium for the root zone that's free of pathogens such as E. coli and salmonella.

Now, some of you may be wondering what the hell a Raspberry Pi has to do with all this. Well, it's such a useful device that it'll carry out two tasks: monitor the garden remotely via a webcam, and detect moisture levels.

Although Linux technology and growing vegetables are the focus of this tutorial, we'll also briefly explain the garden setup and feeding procedure. This will enable you get a grasp how it all ties together.

Although there are many webcams that work out of the box, two very common, affordable cams that often come on sale are Logitech's C170 and C270 models. These can be bought via Logitech's website (**www.logitech.com**) for $40 and $60, respectively.

From the moisture detection side of things, we'll be using a Soil Moisture sensor available from the Mod My Pi website (**bit.ly/soil-moisture**). The device costs about $7, and can be hooked up in minutes. It connects to the Raspberry Pi GPIO pins and the other end is inserted into the plant pot.

As far as accessing the updated watering status goes, two methods will be covered. One uses our Raspberry Pi as a web server; the second accesses a remote website address.

GROW A WEB SERVER

Let's assume we don't have a remote web hosting account to transfer files. No problem: we can use our Raspberry Pi and access it through a browser via your IP address. Every home internet plan sets us up with an IP address. Some are fixed and some are static. We can see our IP address by opening the router software. However, an easier solution is to visit **myipaddress.com**, which will give us the information we need.

Once we know our IP address, we can type it into the browser to see the stream. Note that port forwarding is required to see the web content remotely using our IP address. This can be configured with a router login.

As we mentioned at the beginning of the article, the Soil Moisture sensor will be used to keep an eye on the watering side of things.

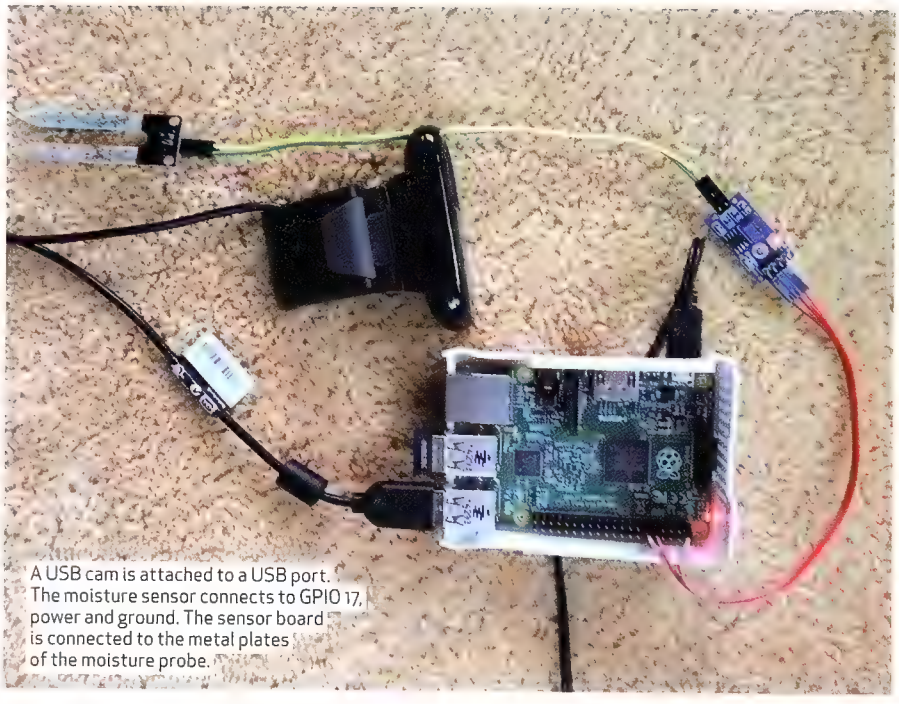
Let's start with the hookup. To assemble the moisture sensor, we connect it to three GPIO pins on the Pi: GPIO 17, power and ground. Afterwards, we connect the sensor board to the metal plates of the moisture probe. The entire kit comes with all the parts. The photo below shows how everything needs to be connected.

With the hookup in place, the unit can check for moisture right away. Thus, all we have to do is stick it into the ground and water a plant. If it detects moisture, two lights illuminate. If not, only one light shines. By default, the output is digital and it uses a simple on/off procedure to detect moisture. With a little time and effort, we could make this setup work for analog output. But we'll keep things simple for this tutorial.

This device can detect when fresh water is added to the plant. But it's not great after that. In an hour or so, after the water has drained away, the moisture detection light goes off.

So if this article was geared towards houseplants, and the light goes out an hour after watering, what good is it if we only need to water them once a week? Not much, to be honest. However, since this article is about hydroponics, the setup is just fine because the plants are on a once- or twice-a-day feeding cycle. Thus, we can easily work with the detection on this level and it'll be as successful as any other device. The water detection can be monitored remotely because we'll be running a daily timer each day to feed the plants with a pump.

The key to this project is that we use a cron job to check the output as either on or off. If it finds that it's on, then we'll receive an alert. This way,



A USB cam is attached to a USB port. The moisture sensor connects to GPIO 17, power and ground. The sensor board is connected to the metal plates of the moisture probe.

Garden in Motion

First off, let's dive into the setup and details of plant monitoring. To do so, we simply install Motion using this command:

```
sudo apt install motion
```

After Motion is installed, we need to edit the file /etc/motion/motion.conf. After it's opened in our usual favourite editor, we just need to change the odd word, such as swapping 'on' to 'off'.

Although the ordering of the lines is spread throughout the file, the listing below shows what these lines should be. If we use the Vim editor, we can use the forward slash and word followed by pressing Enter to find the appropriate line that contains the desired words(s). (*Or with any other sensible editor, 'Ctrl-F' — Ed.*)

```
daemon on

width 640

height 480
framerate 5
ffmpeg_output_movies on
snapshot_interval 60
stream_localhost off
webcontrol_localhost off

vi /etc/default/motion
start_motion_daemon=yes
```

Asides from that, let's make sure it starts automatically on reboot:

```
update-rc.d motion enable
```

The next step is to add an Apache web server and PHP; if none exist on our Pi. PHP will be used if we send files to a remote server and for the simple script used to monitor the watering.

During installation, make sure to type 'Y' and press Enter to ensure the installations occur.

```
sudo apt-get update
sudo apt-get install apache2
sudo apt-get install php7.0 php-pear
libapache2-mod-php7.0 php7.0-mysql
sudo apt-get install php7.0-curl php7.0-
json php7.0-cgi
```

Now, if we reboot the Pi and open the Pi network address like 192.168.1.777:8000, we should see the live stream.

we know whether or not irrigation takes place.

So if we're on the road and we receive an alert at the expected time, we can be confident that our plants won't be flopping over from wilting. This alert is especially useful for the last feeding of the day so we can have a sound sleep, or don't need to call someone to take care of the plants.

MOISTURE ALERT

So let's get down and dirty into the code for detecting moisture and making an alert. Such a small script can be made with Python or PHP.

In our case, we'll use PHP because it has a 'shell_exec()' function that enables us to use raw Linux shell commands instead of using a GPIO library and its functions with Python. Note, though, that PHP also can include a GPIO library that includes an additional install.

So let's take a look at the code below and copy it into a file called moist.php located in the /var/www/html folder. The detailed explanation will follow afterwards. This file can be accessed using the URL **myipaddress/moist.php**. Thus, this file serves a dual purpose: to see the monitoring data output and take a sensor reading.

```
<img src="http://local_ip_
with_motion_service:8081/"
width="320" height="240"/>
<img src="lastsnap.jpg"
width="320" height="240"/>
<?php
$on_off = shell_exec('gpio
read 0');
echo $on_off;
if($on_off == 1){
echo "<br/>It is off";
$fp = fopen('sensor.txt',
'w');
fwrite($fp, $on_off);
fclose($fp);
}else{
echo "<br/>It is on!<br/>";
$fp = fopen('sensor.txt',
'w');
fwrite($fp, $on_off);
fclose($fp);
}
```

Here's how it works. The first two lines display the live stream and latest image taken from the webcam. Then the Linux GPIO library that comes shipped with the Raspberry Pi reads the sensor and returns '1' if dry and '0' if moist.

Just in case we want to record the data, the `fopen()` line up to the `fclose()` line will rewrite a file called sensor.txt, which basically stores the 0 or 1 taken from the reading.

Aside from a pump, 13mm tubing, 13mm feeder lines, 6mm barbed fittings and various 13mm polypipe fittings are used to make the feeding system.

Now that we have the code, let's set up a cron job that runs automatically. In our case, we want it to run twice a day at 10am and 3pm, which is a feeding schedule this author has used in the past. Thus, the five pieces of the puzzle would look like:

```
0 10,15 *  *  *
```

The example below shows a cron job's every minute; one that runs at 10am and 3pm. For those new to cron jobs, let's explain how it works. There are five times to set from left to right: minute, hour, day of month, month, day of week. After the schedule, the command is written as follows:

```
0 10,15 * * * php /var/www/html/moist.php >> /var/www/html/moist.txt 2>&1
```

Because that path to display the image is for the /var/www/html folder, we need to copy the file from /var/lib/motion and give it proper permissions. This procedure will be performed with a cron job as shown below:

```
* * * * *  cp /var/lib/motion/lastsnap.jpg  /var/www/html/test.jpg && chown pi:pi /var/www/html/lastsnap.jpg
```

Here are a few tips regarding the moist.php file. It will check the current status of moisture and write to a file whether you run it in a browser or from a cron job. Towards the end of this article, there's another block of code that just reads the sensor.txt file and displays the result. Therefore, you could always run the moist.php cron job from a path outside of the web directory (for example, /home/pi/moist.php) and just display the output (moisture reading and image) from the /var/www/html directory. This is our recommended option.

REMOTE SERVERS

The plan is to transfer the data to a remote server, but we still need the previous setup for the Raspberry Pi because it takes the photos and reads the watering data. So for the gardening enthusiast who wants to transfer and read the water output and the latest image to a web server, this section will explain that procedure.

FILE TRANSFER

Running Motion, the saved files are timestamped and the most current file is always called lastsnap.jpg. This makes it easy to always keep tabs on the situation. If we have Motion up and running, we can look inside the /var/lib/motion folder and see all the images that had been taken every 100 seconds.

If images are absent in the /var/lib/motion folder, we must make sure it has permissions for the Motion user. Thus, the command `chown -R motion:motion /var/lib/motion` can fix this issue quickly.

There are various methods for transferring files from the Raspberry Pi to the remote server: SCP, FTP, SFTP or FTPS to name just a few. If we keep things simple and are managing both servers with a single admin, then any of these methods are good to use.

On the other hand, if we have cameras from various foreign networks and want all the images on the same remote server, then this will require more work. To do that, we can create FTP accounts for every Raspberry Pi that is carrying out the monitoring. Then each Pi will authenticate and upload the file to its own account.

In the case of multiple machines, each unit will need its own username and password, and the file will be transferred with the `curl` command. That's about it, because once the server interprets the user and password, it already knows which folder will receive the file.

GREEN FTPING

Before we go to much further, let's take a look at the first command, which is a

Although plant stakes work great, this 2-litre-per-hour dripper is supported with a cut-off zip tie.

The basics of hydroponics

Quad pots can be stacked on top of each other. Pots containing tomatoes can be placed two or three high, while peppers (cucumbers, chillis and so on), lettuce and cucumbers can be five or six high.

The pump delivers solution through 13mm poly tubing that has an end cap. Running along the header line are barbed fittings that are inserted into the header line, which connects to smaller tubing. This, in turn, runs to the pots.

At the end of the 6mm tubes are 2-litre per hour drippers. The drippers are held with plant stakes (or, in our case, cable ties). Two drippers in the top pot and individual lines to the lower pots works well. At the very bottom of the system are single 11L pots that can also be planted.

As far as media goes, we can use any hydroponic media of choice, such as a soil-less mix and coco fibre/coir. Any hydroponic plant food will work too, but, the powder option is cheapest. A common food-grade 200L drum can act as the reservoir.

Two tools that are in most hydroponic growers' toolbox are a ph pen and EC/TDS conductivity meter. However, we can reduce costs and just use ph test strips or a liquid test.

A ph of 6.0–6.5 can meet general vegetable needs, while 1,500–1,800ppm (parts per million) works for most vegetables, although lettuce will be fine at 400–500ppm.

Because plants that are grown hydroponically can produce large yields, staking is required for vegetables such as capsicums, tomatoes and jalapeños. Lettuce and cucumbers are low maintenance, while many varieties of tomatoes can simply hang down.

Each column has stacking pots. Each pot holds four plants and column can contain between two and six stacked pots, depending on the plant selection.

Here's the author and his plants in the summer heat. During this time, plants need at least three feedings per day, all scheduled with a timer.

basic FTP transfer. We give the file called send.sh executable rights and the rest just takes care of itself.

In addition, always remember that the file must be executable so it can run. Take a look at the command below and the actual code block shown after that. After these two snippets of code, we will explain the ftp process, which does the same operation like a tool such as Filezilla except automatically.

```
chmod +x /var/lib/motion/
send.sh
#!/usr/bin/env bash

PASSWORD=Member111

HOST='ftp.example.com'
USER='member@members.
example.com'
FILE='lastsnap.jpg'

cd /var/lib/motion
ftp -n $HOST <<END_SCRIPT
quote USER $USER
quote PASS $PASSWORD
binary
put $FILE
quit
END_SCRIPT
exit 0
```

In this script, the universal shebang `#!` line on top refers this file to the bash interpreter. After that, there are the typical username and password credentials that will enable the file to move to a different server. Of course, the file is obvious.

After that, the `cd` command changes to the directory where the file is located – in this case the /var/lib/motion folder. The next command is the big one. It's the actual ftp command that calls the remote host.

The quote commands enable the FTP to bypass, adding a username and password manually and use ours listed in the file to make the connection.

Towards the end, the binary command is there to do the obvious: make the transfer in binary. The `put` command is required to move the file. Once the script runs, it is over.

The line below is a cron job that runs the script send.sh every minute and send the latest picture to a remote server at example.com. The FTP user is created on the remote machine and the software like Cpanel will enable us to manage FTP users and passwords.

```
*/1 * * * * /var/lib/motion/
send.sh > /dev/null 2>&1
```

The same procedure can be used to send the file called sensor.txt that records the sensor reading. The difference is that the sensor.txt file is located in the /var/www/html folder. Thus, the file name and path are the only changes we need to make from the send.sh file example discussed above and the transfer methods that are being shown next. So all we have to do is use the Linux shell `cp` command to make copies of the send.sh file and change the path and filename. Then we copy the cron job to transfer the file and make the filename and path change there as well.

CURLING WITH CANADIANS

Moving on, let's take a look at the other file transfer methods, using `curl` and `scp` :

```
*/1 * * * * /usr/bin/curl
--ftp-ssl -T "/var/lib/motion/
lastsnap
.jpg" -k -u "member@members.
example.com@example.
com:Member111" "ftp://example.
com"
```

SECURE COPYING

```
*1/ * * * *  scp /var/lib/
motion/lastsnap.jpg pi@
ipaddress:/tmp
*/1 * * * * scp -r /var/lib/
motion pi@ipaddress:/tmp
```

The last command sends the entire folder, which can soon become cluttered because there's a new photograph every 100 seconds. Sending the entire directory would be a nice 'see all', but may not be practical because we'll probably want to remove excess files at some point.

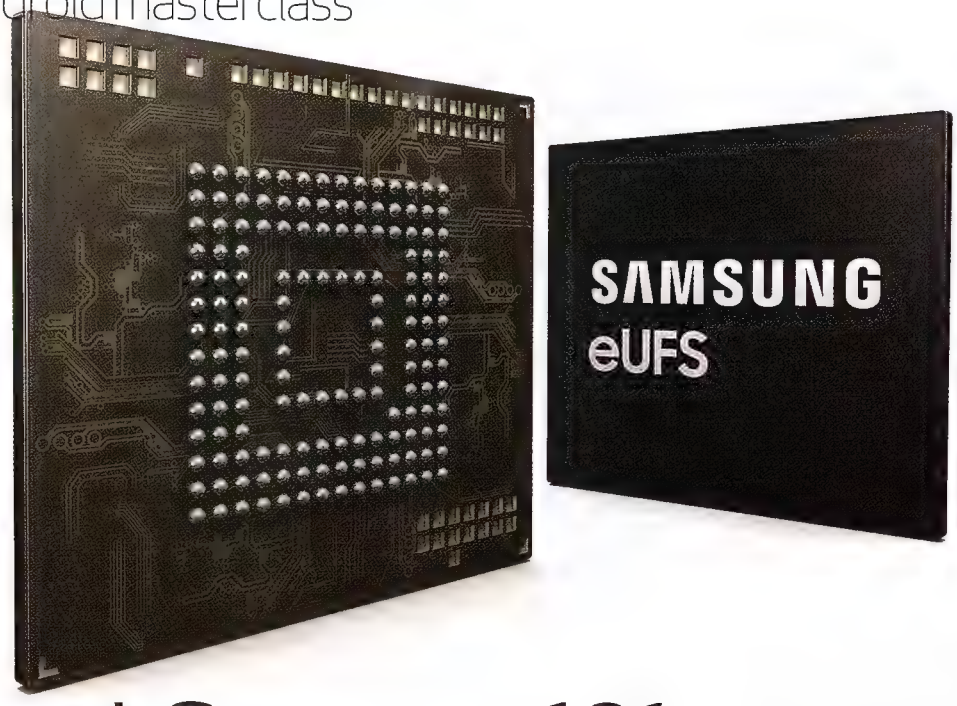
On the remote server, a simple web page will be used to show the latest image and sensor data. That code is displayed next. As a refresher, the sensor.txt file is only recreated twice a day after the pump timer runs in the hydroponic system, which is when we obtain the moisture sensor reading.

To make this setup foolproof, taking the reading 30 minutes to one hour after the pump fires up would ensure plenty of moisture around the probes. As far as the image is concerned, it's updated each minute so we see it in almost real time any time we want.

```
<img src="lastsnap.jpg"
width="320" height="240"/>

<?php
foreach(file('sensor.txt') as
$on_off) {
    //echo $on_off. "\n";
}
echo $on_off;
if($on_off == 1){
echo "<br/>It is off";
}else{
echo "<br/>It is on!<br/>";
}
?>
```

GET GREEN FINGERS!

Well, that pretty much makes it a wrap. We have the tools and techniques to build a garden monitor and view the status from anywhere in the world. In fantasy mode, we can expand our garden or farm to many other locations and keep tabs on all of them – including half way across the world! Good luck and happy gardening.



Samsung's new eUFS flash storage delivers SSD-like performance.

Android Storage 101

Not enough on-board storage? Darren Yates explains the options (and pitfalls) of adding external storage to your Android device.

You can think of smartphones as 'never enough' devices – there's usually never enough battery life, never enough performance and almost always never enough storage. With new models pushing barriers into high-speed Full-HD and 4K video capture, we're fast reaching the point where too much storage isn't enough. As fewer phones arrive with a user-removable battery, external storage through microSD cards is one of the last options for bulking up most existing devices. But it's not without pitfalls.

NEW 'ADOPTABLE' STORAGE

Android 6.0/Marshmallow's arrival heralded new options for phones with a microSD slot. Google calls it 'adoptable storage' (**tinyurl.com/ya7k9kyk**) and it triggers on most devices when Android 6.0 or later first detects a new card, offering you the option to 'adopt' the storage as internal or use it as ordinary 'portable' storage. Adopting the card formats and encrypts the card's contents, locking the card to that particular device, but allows the card to store apps and private data, giving your device the appearance of more internal storage.

However, you can't just pick up the cheapest high-capacity card you can find and expect perfection. Samsung's 2017-flagship Galaxy S8 features 4K (3,840 x 2,160-pixel) video recording with 4K video-bit rates typically set to around 50 megabits per second (Mbps), meaning high-frame rate video capture is heading towards 10MB/second data speeds. At that rate, even the old Class-10 card speed designation barely keeps its head above water.

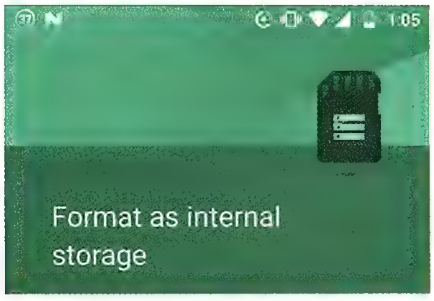
CARD SPEED

Figuring out flash card speeds and ratings is a minefield. The old SD/SDHC 'class' system showed the minimum write speed – Class-4 meant 4MB/second minimum, Class-6 was 6MB/second and so on. The introduction of UHS (Ultra High Speed) bus interfaces in various SDHC and SDXC cards changed how data clocks through the connection between card and device, giving rise to new UHS speed classes. These are labelled on the card as a 'U' with a number inside. A 'U1' card will write 10MB/second minimum, a 'U3' card 30MB/second. What's made this more confusing is there are three UHS interface standards – UHS-I, UHS-II and UHS-III. These are bus interface indicators, not class speeds, but sadly, we've seen these interface indicators confused as speeds. The UHS interface standard is stamped as a standalone 'I', 'II' or 'III' on each card – it means you can have a UHS-I/U3 card or a UHS-II/U1 card. The difference between them is that UHS-II/III cards have a second row of connection pads, while UHS-I cards have just one. These interfaces also have different bus speed limits – UHS-I tops out at 104MB/second, while UHS-II hits 156MB/second full-duplex (simultaneous read/write) or 312MB/

This SanDisk Ultra card has the new 'A1' application performance class rating.

This SanDisk Extreme Pro card is a UHS-II card with U3 speed class.

This SanDisk card is a UHS-I card with U3 speeds and considerably cheaper.



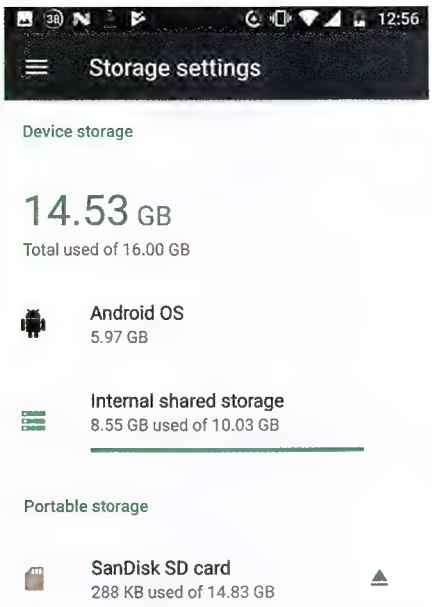
This requires the SanDisk SD card to be formatted to make it secure.

After formatting, this SanDisk SD card will only work in this device.

Formatting erases all data currently stored on the SanDisk SD card. To avoid losing the data, consider backing it up.

ERASE & FORMAT

Android warns you before formatting a card as internal storage.



MicroSD card as portable (left) and device (right) storage.

second half-duplex (read or write). New UHS-III claims up to 312MB/second full-duplex and 640MB/second half-duplex.

At time of writing, no phone supported UHS-II, let alone UHS-III, so there's little point buying UHS-II cards just yet. A good-quality UHS-I Class-U3 card marks the sweet spot.

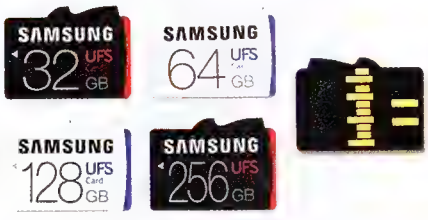
UFS CARDS

More recently, the UFS (Universal Flash Storage) standard, announced back in 2012, has been extended to external flash cards — UFS cards are similar in size but incompatible with microSD and have different guide-locks to prevent false-installation.

UFS cards promise peak write speeds of up to 170MB/second and read speeds of 530MB/second — in other words, near solid-state drive territory. Phone chips from Samsung and Qualcomm have supported UFS going back to at least the Qualcomm Snapdragon 821 and Samsung Exynos 8890. Samsung has reportedly been using UFS flash inside Galaxy phones since the S6 and introduced UFS cards in 2016, but no phone vendor has taken the UFS-card plunge yet. Still, UFS is an official JEDEC (Joint Electron Device Engineering Council) standard, so we reckon you could see phones with UFS cards in the next couple of years.

HOW TO FORMAT

Plug a new MicroSD card into most Android 6.0 or newer phones and it'll automatically bring up the format wizard, but you can choose to reformat the card to internal storage at any time. Open the 'Settings' menu, select 'Storage', tap the MicroSD card listed under 'Portable storage', tap the three-dot options menu, choose 'Storage settings' and tap 'Format as internal'. You'll get a warning about encryption and erasing the card (backup everything first), then tap 'Erase & Format' when you're ready. After it's completed, you'll get the option to move files to the card either now or later — your choice, however, some apps won't work while the move is underway and in our experience, the process took two minutes to move around 1.5GB of data.



UFS flash cards are not compatible with microSD but offer faster speeds.

REASONS TO AVOID IT

The problem is reformatting the card from internal back to portable storage. You can, but you shouldn't. Any apps, any personal or app data moved to the card has to be moved back to the phone or backed up before the card is reformatted as portable storage or it'll be lost — and Android doesn't move it for you. It's said Android will uninstall any apps on the microSD card before the card is erased, but that's it. Moreover, formatting a microSD card as 'internal storage' could well affect phone performance. Adding slow flash cards to higher-speed internal or 'embedded' flash storage slows down the storage overall and the phone's performance.

You can't use file-based encryption (FBE) together with adoptable storage, but there's also the potential issue of microSD card endurance. All flash storage slowly kills itself every time you write to it and phones use wear-levelling techniques on internal storage to spread the wear evenly. When used as portable storage, microSD cards store files like videos and photos — typically, it's a write-seldom-read-often data transfer model. When used to store apps and private data, however, it's not clear how Android manages the extra write activity wear on adopted cards.

APPLICATION PERFORMANCE CLASS

The new Application Performance Class rating system appearing on new microSDHC/SDXC cards aims to rate cards for application speed — these cards are rated not just for sequential read/write speeds like standard cards, but also random read/writes, ratings more suited for apps. Class-A1 cards are rated at 1,500 IOPS (input/output operations per second) read and 500 IOPS write. Class-A2 cards are much faster, rated for minimum 4,000 IOPS random-read and 2,000 IOPS random-write. Both classes have a minimum sequential write speed of 10MBps.

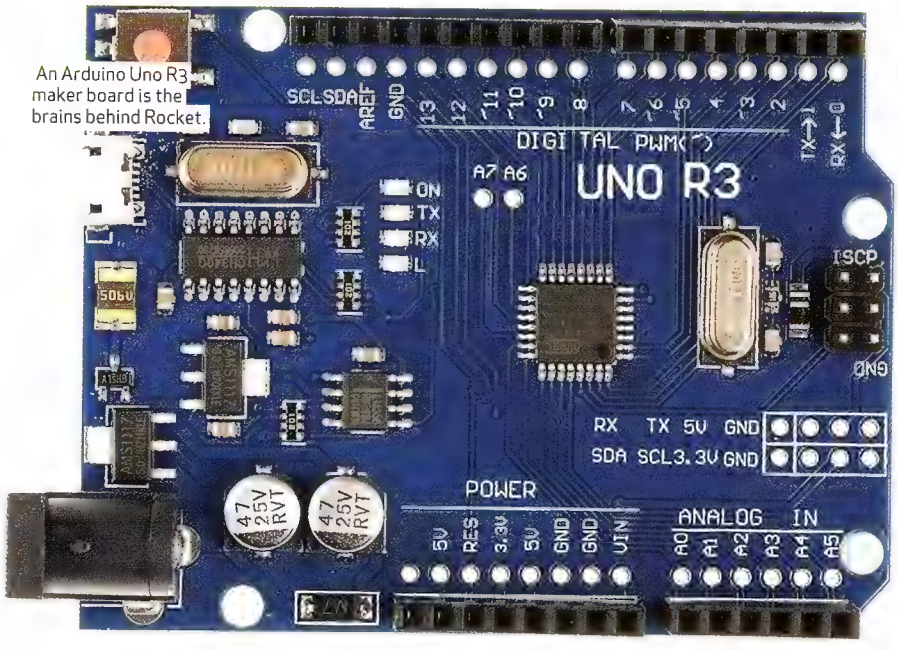
CHOOSING THE RIGHT CARD

Embedded flash storage will always be faster than external cards, and right now, using adoptable storage will likely slow down your phone's performance. The arrival of UFS or UHS-II cards with their higher write speeds still won't match embedded storage, but as speeds overall increase, the speed differential should be less noticeable. In the meantime, know your phone's fastest interface and buy as much storage for that interface as you can wisely afford — and keep it as portable storage.

Meet Rocket, our DIY autonomous robot

Is a chassis necessary to build a robot? Darren Yates dived in to find out and in the process, created Rocket, a little chassis-less Arduino robot. Here's how it happened — and how you can build one too.

Building an autonomous robot is a pretty awesome way to learn the ins and outs of Arduino and, over the years, we've built several robots within these pages. However, they've all required a commercial kit or chassis to make, which is fine – until the kit is no longer available. That made us wonder whether it was possible to make an autonomous robot just from the circuit boards, motors and other raw parts left over from previous robot builds, without a kit or plastic chassis holding it together. After much pencil-chewing, trips to the hardware store and the odd ounce of luck, Rocket, the no-chassis autonomous robot, was born.



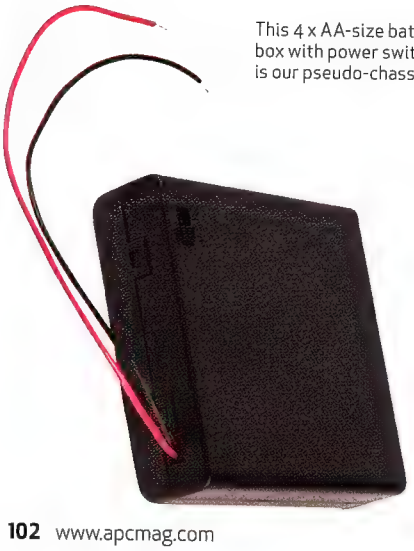
An Arduino Uno R3 maker board is the brains behind Rocket.

NO CHASSIS?

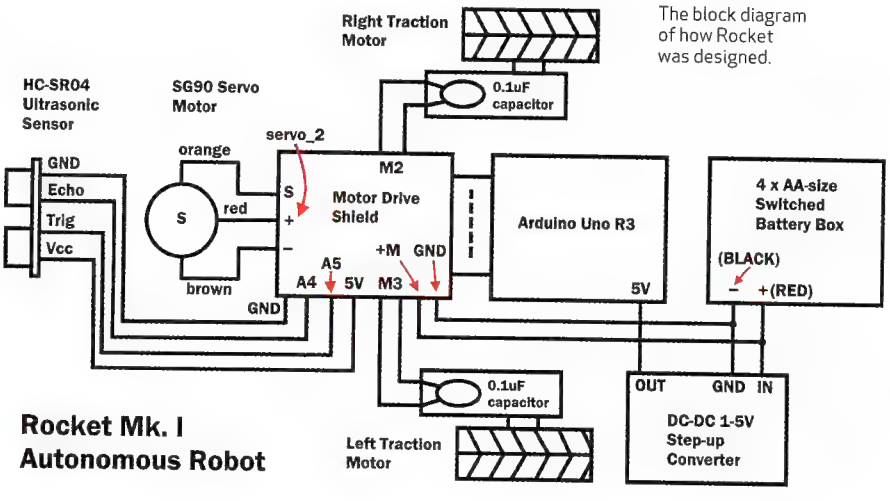
The simplest way to build an autonomous robot is to start with a basic kit – there are plenty of options around, usually consisting of a plastic chassis base, mounting components, a couple of TT geared motor/wheel combos and a castor wheel of some description. You're usually left to provide the electronics and software code yourself. The problem was, none of the available kits were all that appealing – they were all just a bit plain. Our very first robot, the 'Rolly' Mk I, was built on the lid from a kitchen food container – it looked terrible, but it was much more fun to make than most ready-to-build kits we've tried. So in that same spirit, we stared at a bunch of components, scratching our heads at how to create a chassis-less autonomous robot.

ROBOT DESIGN

A basic robot design needs a minimum tricycle undercarriage – two powered wheels to drive and steer, plus a universal trailing/leading castor wheel for stability. You can have four-wheel drive if you want, but the extra motors add little beyond extra load onto the battery. We already had a couple of spare TT motor/wheel combos, what we didn't have was the castor wheel. Nor did we have anything to attach them to. Leaving that aside, the electronics was always going to be fairly straightforward – an Arduino Uno R3 board with a Motor Drive Shield on top would take care of almost everything.



This 4 x AA-size battery box with power switch is our pseudo-chassis.



The block diagram of how Rocket was designed.

Rocket Mk. I Autonomous Robot

An HC-SR04 ultrasonic sensor attached to a tiny SG90 servo motor would serve as the eyes and neck. What's great about the Motor Drive Shield is that it's designed for this task — not only does it support up to four DC motors, it has two servo motor connection points, plus extra connections to the analog input/output pins ideal for the ultrasonic sensor.

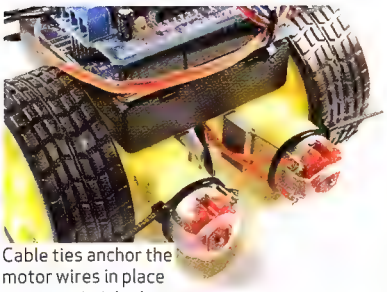
GETTING POWER

The next question was how to power this robot. Some online designs use two batteries — a 9V PP3 battery to drive the Arduino board and a 6V battery to run the motors; others drive everything with multiple AA-cell packs. Having two batteries is just more work, so to keep things manageable, this would be a 6V-battery design based on four 'AA' NiMH cells — they're cheap, rechargeable and easy to find. Online retailers sell a battery box with built-in power switch designed for four 'AA' cells and that's when it dawned on us — the battery box could serve as a pseudo-chassis. After playing around with the layout for a bit, it worked out that the motors could be anchored to the under or 'switch' side of the battery box, while the electronics sit on the box top. Since the top came away from the battery box bottom, the AA cells themselves were still accessible, enabling them to be replaced and recharged. However, being NiMH rechargeable cells, this was more accurately a 5.5V-battery design, which would have ramifications later on.

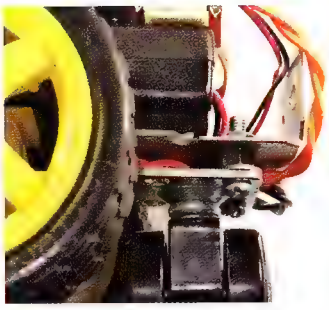
ANCHORING THE WHEELS

The battery box wasn't designed with anchoring motors in mind, so the next best option was to try double-sided foam tape — this stuff sticks like the proverbial to a blanket. However, even before using the tape, it was clear there'd be little room to mount a castor wheel after the motors were in place. This was tricky because there needed to be enough surface area between the battery box and motors for the double-sided tape to grip, but not so much as to overly shorten the wheel-base (the distance between the drive wheel and castor wheel axle-centres) and make the robot tip over.

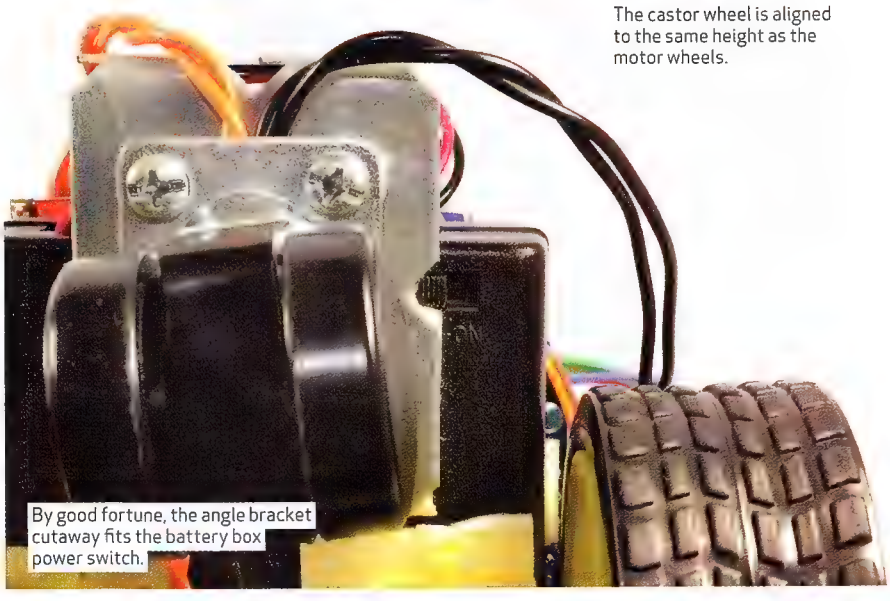
Hardware stores are great places to wander through and while searching for a suitable castor wheel, we found some useful 1mm-thick galvanised-steel right-angle brackets. They're made by Carinya in China and measure 25 x 50 x 40mm — Bunnings have them for $1 each. The 50mm-long base could attach via double-sided tape to the battery box underside and would provide enough added length to enable a small universal castor to rotate through 360-degrees. The 25mm 'lip' facing up would also act as a bumper-bar ahead of the ultrasonic sensor. Things were



Cable ties anchor the motor wires in place to prevent stripping.



The castor wheel is aligned to the same height as the motor wheels.

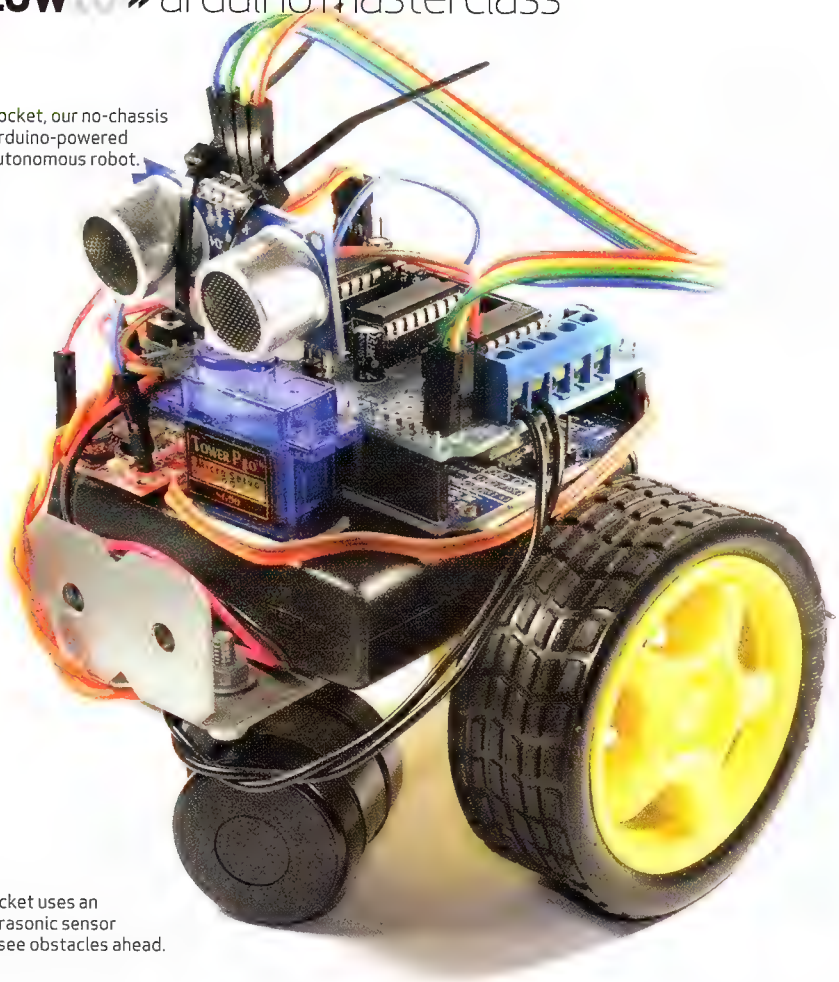


By good fortune, the angle bracket cutaway fits the battery box power switch.

"A basic robot design needs a minimum tricycle undercarriage — two powered wheels to drive and steer, plus a universal trailing/leading castor wheel for stability."

ROCKET ROBOT — PARTS LIST

PART	COST PER UNIT	QTY	SOURCE
ARDUINO UNO R3	$5.00	1	EBAY
L293D MOTOR DRIVE SHIELD	$4.00	1	EBAY
DC-DC 5V STEP-UP VOLTAGE CONVERTER	$1.00	1	EBAY
TT GEARED MOTOR/TYRE COMBO	$2.00	2	EBAY
HC-SR04 ULTRASONIC SENSOR	$2.00	1	EBAY
TOWERPRO SG90 SERVO MOTOR	$3.00	1	EBAY
4 x FEMALE-TO-FEMALE JUMPER WIRES	$2.00	1	EBAY (ONE PACK)
SCOTCH/3M MOUNTING TAPE 2.5CM x 1.9M	$6.00	1	BUNNINGS, MITRE 10 ETC
16-METRE HOOKUP WIRE PACK	$5.00	1	JAYCAR
0.1UF/50VW CERAMIC CAPACITORS	$0.50	2	JAYCAR
120MM CABLE/ZIP TIES	$2.00	1	EBAY, JAYCAR, BUNNINGS ETC
DIP PIN HEADERS	$1.00	1	EBAY, JAYCAR
4 x AA BATTERY BOX WITH SWITCH	$1.00	1	EBAY
4 x AA-SIZE NIMH RECHARGEABLE BATTERIES	$7.00	1	COLES (4-PACK)
CARINYA 25 x 40 x 40 x 1MM BRACKET	$1.00	1	BUNNINGS
AMBASSADOR 30MM UNHOODED CASTOR WHEEL	$4.00	1	BUNNINGS (2-PACK)
BOLTS, NUTS, WASHES ETC	$1.00	1	BUNNINGS
TOTAL COST (APPROX.)	$50.00		



Rocket, our no-chassis Arduino-powered autonomous robot.

Rocket uses an ultrasonic sensor to see obstacles ahead.

starting to look up. The choice of castor wheel ended up being a 30mm Ambassador-brand unhooded plate furniture castor – these were $3.50 for a two-pack from Bunnings.

ELECTRONICS ON TOP

By good luck more than good management, the Arduino Uno R3 board and the Motor Drive Shield dimensions are just smaller than the battery box, so having these sit on top wouldn't be a problem.

One slight annoyance was that the Motor Drive Shield had no header pins installed for the analog input/output, Vcc and GND pins. While the shield had dedicated pinouts for the servo motor, setting up the ultrasonic sensor would have to be a 'home-brew' job. Many eBay component retailers sell a row of 40 pin-headers spaced at 0.1-inch intervals for about $1 – these snap off easily to the desired amount and were soldered into position. The HC-SR04 sensor requires four connections – two for power (Vcc and GND), another two for data: one 'send' (trigger) and one 'receive' (echo).

WIRING UP THE MOTORS

Ordinary hook-up wire from Jaycar was used to wire up the motors. To reduce electrical noise from the motors feeding back into the Motor Drive Shield, 0.1uF capacitors were soldered across the motor connections. The wires were then cable-tied, twisted and brought up to the Shield and installed into motor outputs M2 and M3. The SG90 servo motor slotted into the 'servo_2' connection and the HC-SR04 sensor connected using dupont wires.

Four fresh AA-size NiMH rechargeable batteries were installed into the battery box, the source code flashed to the Arduino Uno and after checking everything twice, the battery power switched on.

INTERMITTENT PROBLEMS

The problem was, it just didn't work properly. The code was checked and everything seemed to be connected up correctly – it only worked intermittently and intermittent issues are the worst to try and troubleshoot.

When troubleshooting, it always pays to start with the power source because if the power isn't right, nothing else will be. Everything here was wired up correctly, but the problem turned out to be my decision to use rechargeable batteries. Forget what's written on the label – a fully-charged NiMH cell can give as much as 1.4VDC and four together around 5.5VDC, but drop nearer to 5VDC under load.

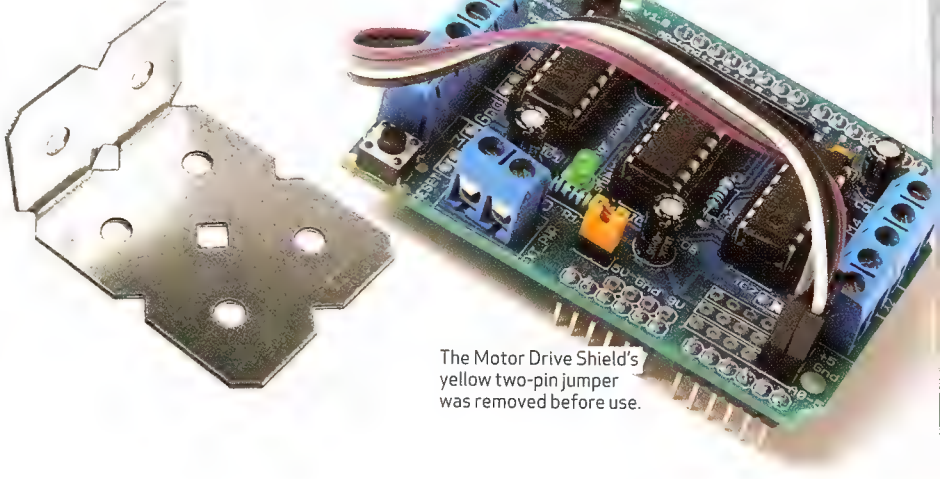
The way a Motor Drive Shield is normally used is to apply the main motor drive power directly to the Shield's EXTPWR terminal block (+M and GND) and choose whether or not to also send that same power down to run the Arduino Uno board by setting the two-pin PWR jumper. With the jumper in place, that motor voltage goes down to the Arduino Uno's 'Vin' power-input pin – and this was where the problems started.

The Vin input connects to a 5VDC linear voltage regulator, which aims to generate a nice, clean 5VDC voltage rail to run the Arduino Uno with. The problem was, the regulator needs 7VDC minimum on that Vin pin to work correctly and it was only receiving 5.5VDC at best. It was enough to start the Arduino Uno, but as soon as the motors kicked in and the battery voltage dropped as a result, the Arduino Uno's microcontroller chip didn't have enough voltage to run and just turned off. Now with no load on the battery, the voltage rose again just enough to restart the Arduino Uno, setting off a nasty boot-loop. Basically, this robot build was starting to go pear-shaped.

STEPPING UP

Yet it wasn't a total disaster – the designers of the Motor Drive Shield had cleverly allowed for the option of separating the motor drive power from the drive electronics through that simple two-pin 'PWR' jumper. With the jumper in place, the Motor Drive Shield's power runs the Arduino. Remove the jumper and the Arduino Uno's power rail is now separate.

This 25 x 50 x 40 x 1mm angled bracket is double-sided taped to the battery box.



The Motor Drive Shield's yellow two-pin jumper was removed before use.

This provided the germ of a solution. One of the many gazillions of gadgets you'll find on eBay is a tiny 1-5V DC-DC step-up converter module – through some very clever design tricks, this device accepts anything from 1V to 5VDC voltage input and 'steps it up' to a steady 5VDC output at up to 500mA of current. Essentially, it provides a second (more or less) independent voltage rail. The problem now was how to connect it into the setup – and this required some trickery of our own.

The way the Arduino Uno is wired, the voltage on the Vin input connects to the 5VDC voltage regulator and the 5VDC output of the regulator drives the Arduino Uno electronics. The Arduino itself provides an external link to this regulated 5VDC output for use elsewhere. However, what's not commonly understood is that, if the Vin input isn't being used, the regulator can be bypassed and the 5VDC rail driven directly – it's essentially what USB power does here. Nevertheless, in bypassing the regulator, you now take responsibility for feeding the Arduino the correct voltage – muck it up and you can blow up the Arduino's brain, the ATMEGA328 microcontroller chip. That said, the Motor Drive Shield very neatly provides numerous points to access this common 5VDC rail, so it was just a matter of removing the jumper, connecting the 5VDC output from the DC-DC step-up converter to one of the '5V' pins on the Motor Drive Shield and we were back in business. So now, the battery directly powers the motors via the EXT_PWR terminal block, while the DC-DC step-up converter powers the Arduino Uno. All is well.

This seems a complicated method just to avoid a second battery, but now there's only one battery to deal with – and NiMH AA-cells are more convenient than a 9V battery.

SOURCE CODE AVAILABLE

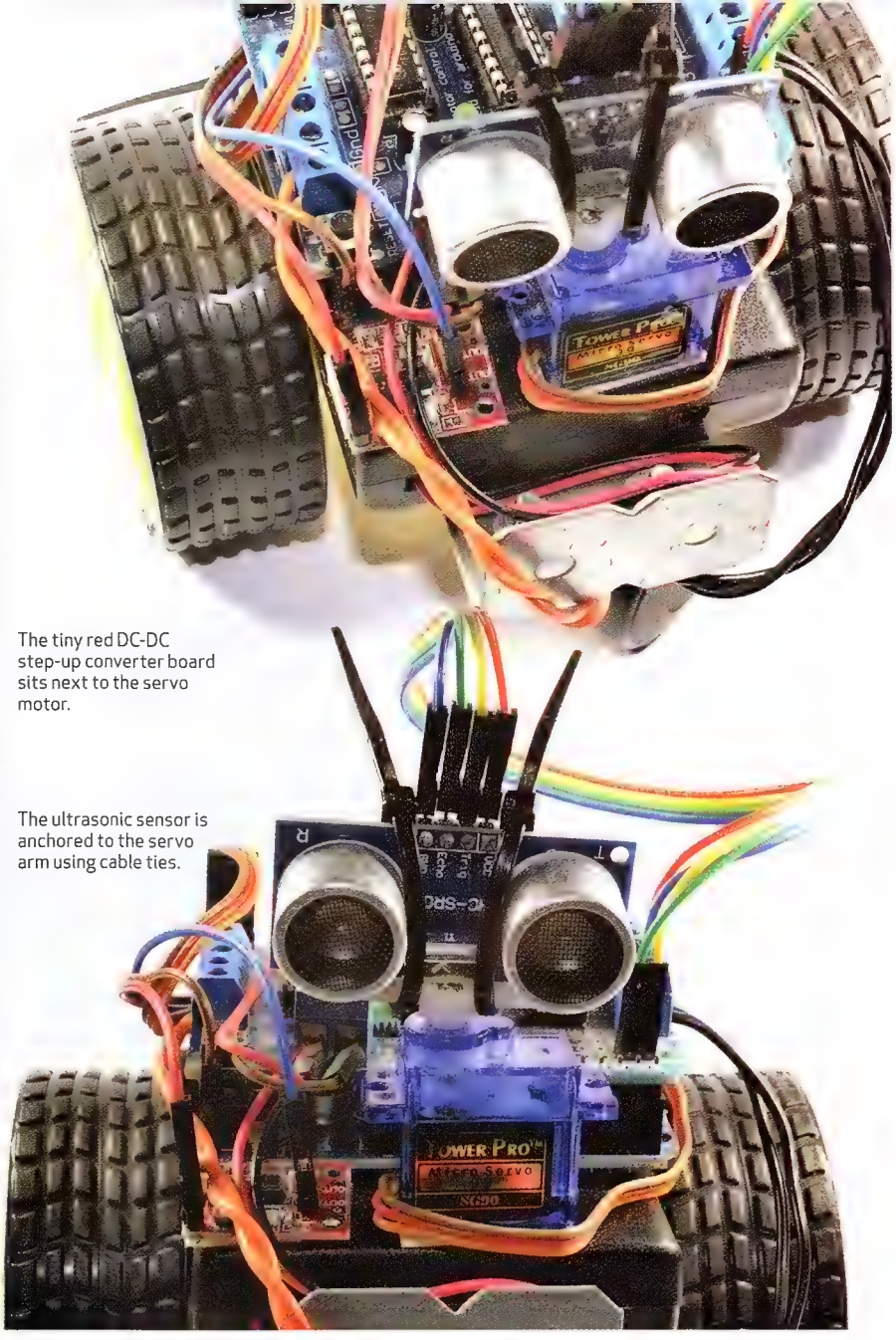
A word of warning – if you're thinking of having a crack and building your own version, know this is not a simple task. Because of the unstructured nature of this build, it's not recommended for inexperienced builders and we cannot provide reader support. That said, we're making the source code available on our website at **apcmag.com/magstuff**.

We've listed the parts we used to build Rocket, but only as a guide for your own design. Provided you follow the same component layout shown in the block diagram, the source code should still work, even if your bot looks completely different.

NIMH BATTERIES ONLY

Another thing, by using the DC-DC step-up converter module here, we cannot use standard 1.5V alkaline or Lithium AA cells – the combined 6V voltage from the four cells will likely swamp the DC-DC converter's ability to regulate the output. The resulting voltage to the Arduino board may exceed the maximum 5.5V allowed and blow it up.

As NiMH cells also have a lower internal resistance, great care was required to check all wiring was correct and to ensure no short-circuits or reverse-polarity wiring occurred, which could cause catastrophic damage to the electronics or the NiMH cells.



The tiny red DC-DC step-up converter board sits next to the servo motor.

The ultrasonic sensor is anchored to the servo arm using cable ties.

TOP TIPS

We did have some luck during the build – the Ambassador-brand 30mm castor wheel had mounting holes that matched those on the angled bracket. We used 20mm M4 bolts and sufficient nuts and washers to offset the castor wheel height to match the drive motor wheels. This gave Rocket consistent height when the castor wheel moved through a full rotation.

The double-sided tape worked well for the components on top, but after a while, it stopped gripping the motors – we haven't tried it but a hot glue gun should make short work of this issue.

LEARNING THROUGH TRIALS

In the end, our little robot build was a success, and with our rose-coloured glasses, it reminds us a bit of Robert Stephenson's 1829 'Rocket' steam locomotive. We couldn't think of a better name.

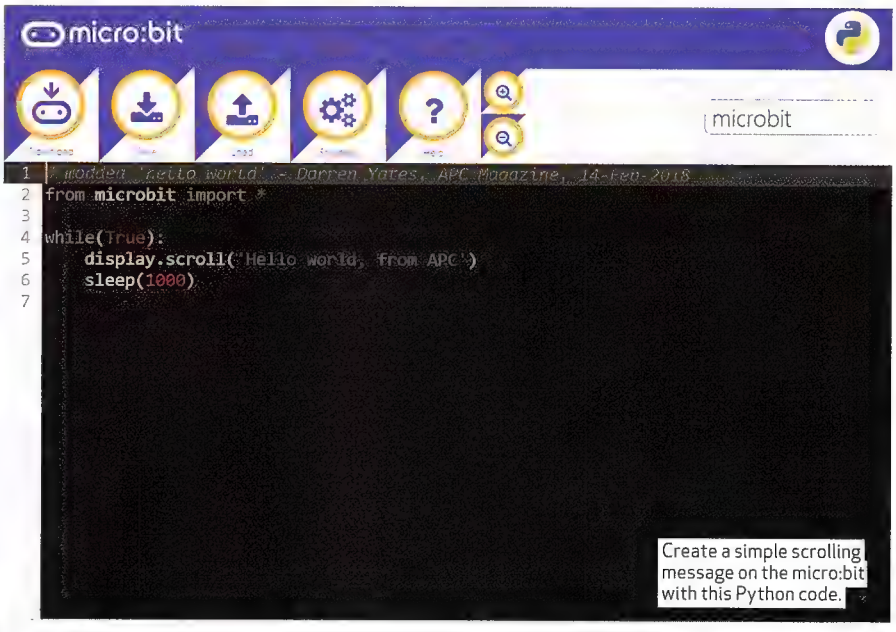
Is it the best way to build a chassis-less robot? Of course not. It's just one way – we're sure you can think of ways to improve it. One of the key skills to have when making your own tech is the ability to troubleshoot. More often than not, this leads into problem solving, looking at a problem from different angles and finding a solution that works. After that, tenacity, resilience and resourcefulness round out the top-five skills gained.

Still, these aren't just good Arduino skills – they're great life skills and it's amazing how gaining confidence in one area can give a boost in another. ■

Make micro:bit gadgets with Python

Looking for a maker board suitable for the classroom? The BBC micro:bit is a simpler alternative to the Raspberry Pi and you can code it with Python. Darren Yates explains.

Learning to code is rarely for coding's sake. You learn because you want to write an app to solve a problem or achieve some result. One of the reasons I code is because I love to build stuff – skip back a few pages and you'll see our Arduino Masterclass, where we're always building stuff or looking at new gear and techniques. However, many of the 'Arduino'-grade of maker boards require knowledge of programming based on the more complex C++ language. Still, they're not the only option – jump aboard the BBC micro:bit and you can code your own gadgets using a basic form of Python 3.



Create a simple scrolling message on the micro:bit with this Python code.

THE BBC MICRO:BIT

The BBC micro:bit is a small circuit board designed by the British Broadcasting Corporation (yep, *that* BBC), aimed primarily at helping teach kids how to code. It's about size of a credit card and plugs into a standard USB port via a microUSB cable enabling you to program it via any computer. The board itself has a mini-processor on board called a 'microcontroller', which has a 32-bit processing core running at 16MHz, a small cache of 16KB of RAM, 256KB of flash storage and built-in Bluetooth Low Energy (BLE) wireless connectivity. Sure, a 16MHz processor, 16KB of RAM and 256KB of storage doesn't sound like much, but you're not running Microsoft Windows here – the microcontroller only has one app to run and that's the one you code. As a result, there is plenty of speed available to perform a range of tasks.

In fact, the board also comes with lots of extra features that make it really cool, even features you'll find in many smartphones. There's a 5x5-grid of LEDs you can code individually to make games or write scrolling text, as well as two pushbutton switches on either side to help. Next, there's an accelerometer – it measures changes in physical position and is the same type of device your smartphone uses to notice changes in orientation between portrait and landscape. After that, comes a device called a magnetometer, a tiny silicon chip that can measure changes in magnetic fields, so you can use it to make a magnetic compass, a metal detector, even detect electricity.

Not only can the micro:bit be coded and powered via the microUSB port, it also features a battery input to run the board externally from two triple-A-size alkaline batteries. In terms of price, you can buy a micro:bit in Australia for around $22, so it's a bit more expensive than a Raspberry Pi Zero, but about a third of the price for a Raspberry Pi 3. I purchased the 'micro:bit go' package, which includes the board, USB cable and battery pack for $32 including local shipping.

SIMILAR, BUT DIFFERENT

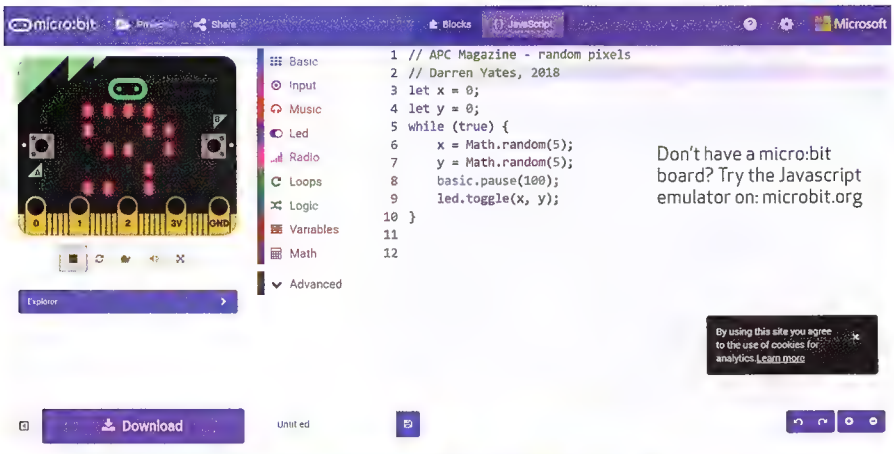
The comparison with the Raspberry Pi isn't strictly fair because, although most 'maker' boards do get lumped together, the Raspberry Pi is a completely different beast to the micro:bit. The Raspberry Pi is a genuine full-scale general-purpose computer board – it's designed to run a desktop operating system in Linux, run any number of different applications via external storage, even output video via HDMI to a monitor.

The micro:bit, on the other hand, is completely different – it's designed for what are called 'embedded' applications, where it just has one job to do: running your source code directly on its internal processor. In that regard, it has far more in common with Arduino than it does with the Raspberry Pi, and without that full-scale operating system, the micro:bit is actually easier to work with. If you're a tech teacher,

The micro:bit board is about the size of a credit card.

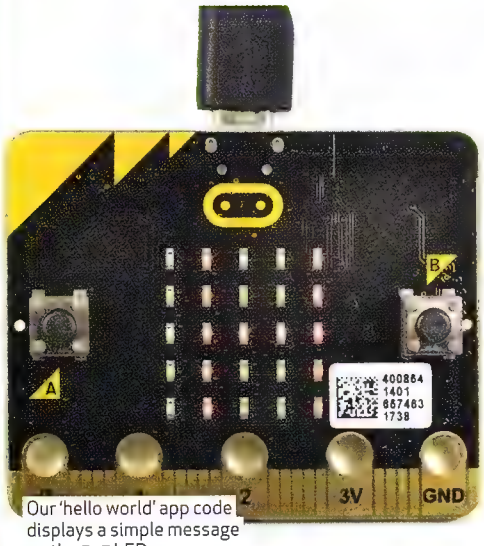
```
# X-Y Spirit-Level - Darren Yates, APC Magazine, 14-Feb-2018
from microbit import *

while(True):
    x = accelerometer.get_x()
    y = accelerometer.get_y()
    splevelX = 2 - int(x/64.0)
    splevelY = 2 - int(y/64.0)
    if (splevelX < 0):
        splevelX = 0
    if (splevelX > 4):
        splevelX = 4
    if (splevelY < 0):
        splevelY = 0
    if (splevelY > 4):
        splevelY = 4
    display.set_pixel(splevelX, splevelY, 9)
    sleep(100)
    display.clear()
```

Make a spirit-level with this Python code using the micro:bit's accelerometer.



Don't have a micro:bit board? Try the Javascript emulator on: microbit.org

"It's about size of a credit card and plugs into a standard USB port via a microUSB cable enabling you to program it via any computer."



Our 'hello world' app code displays a simple message on the 5x5 LED array.

The 'micro:bit go' pack includes board, battery pack, USB cable and batteries.

it's well-suited to the classroom and best of all, you can code it with Python!

CODING VIA A BROWSER

Last month, we looked at ways to code Python online using just your web browser – it's also the way you code up the micro:bit. Head to **microbit.org/code** and you'll quickly discover three coding options for this little board – there's a block-style version of Javascript similar to Blockly, there's a more traditional text-based Javascript option and then there's a mini version of Python called 'MicroPython'.

If you've got Javascript skills, you don't even need a micro:bit board to get started – the website has a more-than-passible on-screen emulator that accepts 'soft' input and emulates the board's LEDs. For the time being at least, the MicroPython option provides only a coding window (no emulator), but given we've spent a good deal of time learning Python in this column, we should be able to turn the micro:bit into something useful.

HOW CODING WORKS

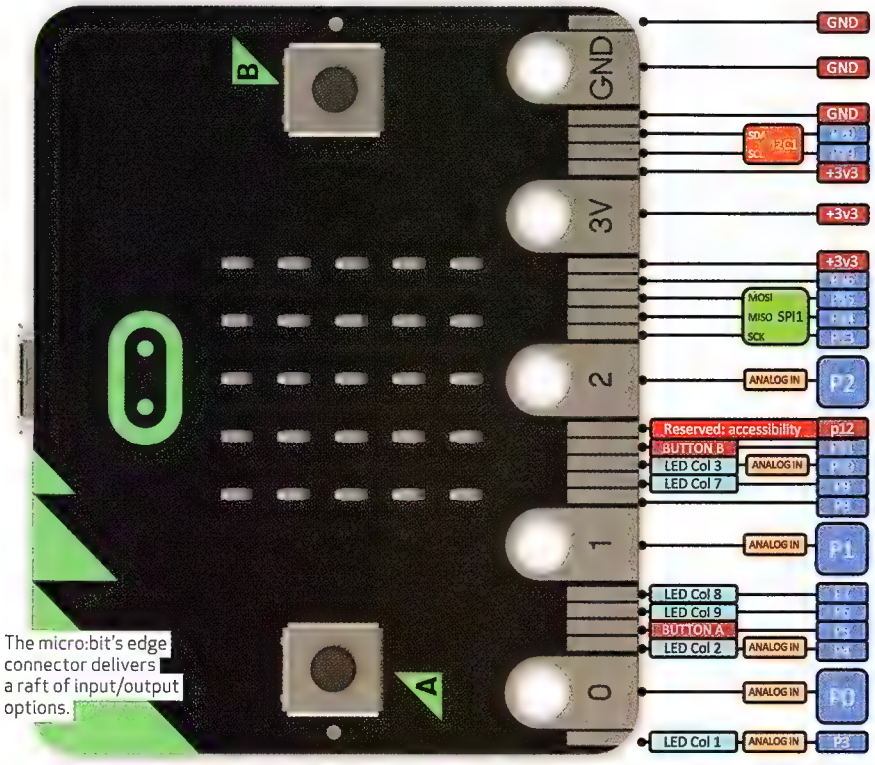
We'll assume you're using a Windows computer for this next bit, but no matter which language option you choose, coding the micro:bit follows the same basic process. First, you write your source code on the micro:bit web interface. Next, you press Download and receive a '.hex' file that contains a special compiled version of both your code and code engine designed for the micro:bit's microcontroller chip.

Plug your micro:bit board into your PC's USB port and it should appear as a new storage drive within Windows Explorer. Drag-and-drop the hex file across to the new 'MICROBIT' storage folder, and as soon as you do, the micro:bit board lights up the LED on the back, indicating the code is being written or 'flashed' to the microcontroller. When completed, the storage folder will self-eject from your computer and the micro:bit should automatically restart, launching your code. The folder returns in Windows Explorer almost instantly, but your file will no longer be there – after it's flashed to the microcontroller chip, the file is removed from the storage drive automatically.

So really, if you can drag and drop a file into a Windows Explorer folder, you can flash source code to a micro:bit board, making it suitable for newbie and pro coders alike.

SAFETY TIPS

The board comes with a number of safety recommendations, including handling the board by the edges only and only using alkaline or carbon-zinc batteries. Reasoning for the latter isn't specified, but we believe it's to do with



The micro:bit's edge connector delivers a raft of input/output options.

avoiding accidents if you decide to start adding external components to the board. Alkaline and carbon-zinc batteries have what's called a 'higher internal resistance' compared with NiMH and LiPo rechargeable batteries, which means they cannot pump out electrical energy as quickly in the event of an accidental short-circuit. Still, there's plenty of stuff you can do with a micro:bit board without letting loose your inner electrical engineer just yet.

HELLO WORLD!

Each micro:bit board comes with a built-in demo that begins as soon as you plug in power or the microUSB cable into your PC, but if you've been following our Python series, you'll be in good shape to start coding the micro:bit with Python. The one thing to be aware of is that, in order for the MicroPython code engine to fit into the small amount of storage inside the micro:bit's microcontroller, a chunk of the original Python code is missing, making MicroPython a subset of the Python 3 standard library. In other words, a lot of Python is there, just not everything.

To show how it works, we'll start with the 'hello, world' of coding – displaying "hello, world" on the micro:bit's 5x5 LED array. The first line for any micro:bit Python app is:

```
from microbit import *
```

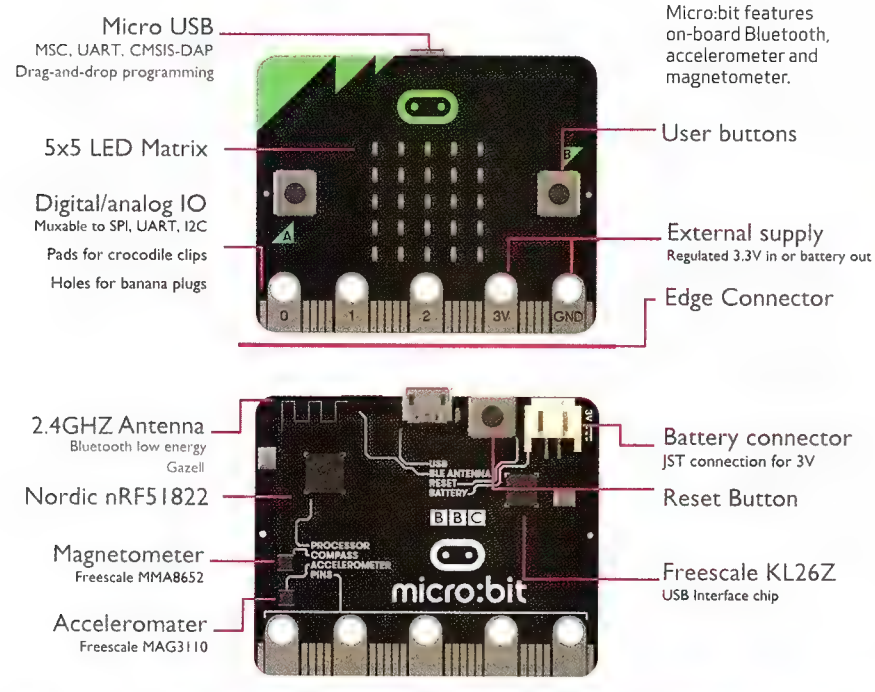
...which means import any and all modules from the microbit library as are needed. Wildcard (*) import statements are frowned upon in some circles, but in the interests of simplicity, the micro:bit's Python team suggesting you use one here is understandable.

To have our message scroll and display continuously, we add a while-loop like this:

```
while(True):
 display.scroll('Hello world, from APC')
 sleep(1000)
```

The while-loop has a parameter 'True' – remember that a while-loop continues looping until its loop parameter evaluates to 'False', but since the parameter here is 'True' and always will be, the loop continues indefinitely. The code within the loop appears one tab-indent in and here, we have two statements – first, the 'display.scroll()' command, followed by a 'sleep()' statement. The display.scroll() function is obvious enough and the sleep() function pauses code operation for the parameter integer value in milliseconds, so '1000' gives us a one-second delay before the while-loop begins again.

Now press the download button on the microbit Python webpage, download the .hex file, plug in your micro:bit board, copy the .hex file to the 'MICROBIT' folder and within a few seconds, you'll be 'hello world'-ing.



SPIRIT LEVEL

Now let's try something more complex. One of the cool features on board the micro:bit is the accelerometer chip. It works just like the one in your phone, so let's turn the micro:bit board into a spirit-level, combining the accelerometer and the 5x5 LED array (if you haven't come across one before, a spirit level is an instrument used for checking if a surface is perfectly horizontal or vertical). You can view the code in our code screen-image.

The 5x5 LED array becomes our 'map' with the centre LED as our 'level' mark – the LED array works like a X-Y coordinate chart with top-left denoted as (0,0), top-right (4,0), bottom-left (0,4) and bottom-right (4,4). If the middle LED (2,2) is lit, it means the board is

micro:bit developer community

horizontal in both the X- and Y-axes. All of our code sits within a while-loop as before and the first thing we do is read the accelerometer data. Accelerometers work in three axes – X (left-right), Y (forward-back) and Z (up-down). We only need the X and Y axis data in this example, so we use the statements:

```
x = accelerometer.get_x()
y = accelerometer.get_y()
```

The 'accelerometer' object uses two functions – 'get_x()' and 'get_y()'. These return the g-forces recorded in these two axes in 'milli-g' into variables 'x' and 'y'. Values range from -2048 to +2048. If the variables 'x' and 'y' hold values of '0' and '0', that means the board is horizontal in both axes.

However, we've got a few issues to fix with the data. First, the value range is too great, so we must scale it down and we do that by dividing it by 64. Why 64? We want to reduce the value range, but not overly reduce the sensitivity (how much you need to tilt the board to register that it's off-centre). To reduce sensitivity further, try dividing by 128 or 256 instead.

The other problem we've got is that 'centre' for the accelerometer X and Y axes data is (0,0), but for the LED array, it's (2,2), so we need to offset the accelerometer data so that (0,0) maps to (2,2) on the LED array. Complicating things a step further, we also want the display to move like a spirit level, meaning the LED moves in the opposite direction of tilt, just like the bubble in a spirit-level.

We fix these issues by starting the variables 'splevelX' and 'splevelY' with a value of two and subtracting the scaled accelerometer value from it – this centres the data and reverses or 'inverts' the movement at the same time. The code for each axis is:

```
splevelX = 2 - int(x/64.0)
splevelY = 2 - int(y/64.0)
```

The 'int()' function turns the scaled floating-point value inside the brackets into an integer (whole number).

The last problem is we need to ensure the values for 'splevelX' and 'splevelY' do not exceed the range of 0 to 4, otherwise, when we try to set the LEDs to light up using the 'display.set_pixel()' command, we'll get an 'out of bounds' error. We fix this using a series of four if-conditional statements that stop the values exceeding these limits.

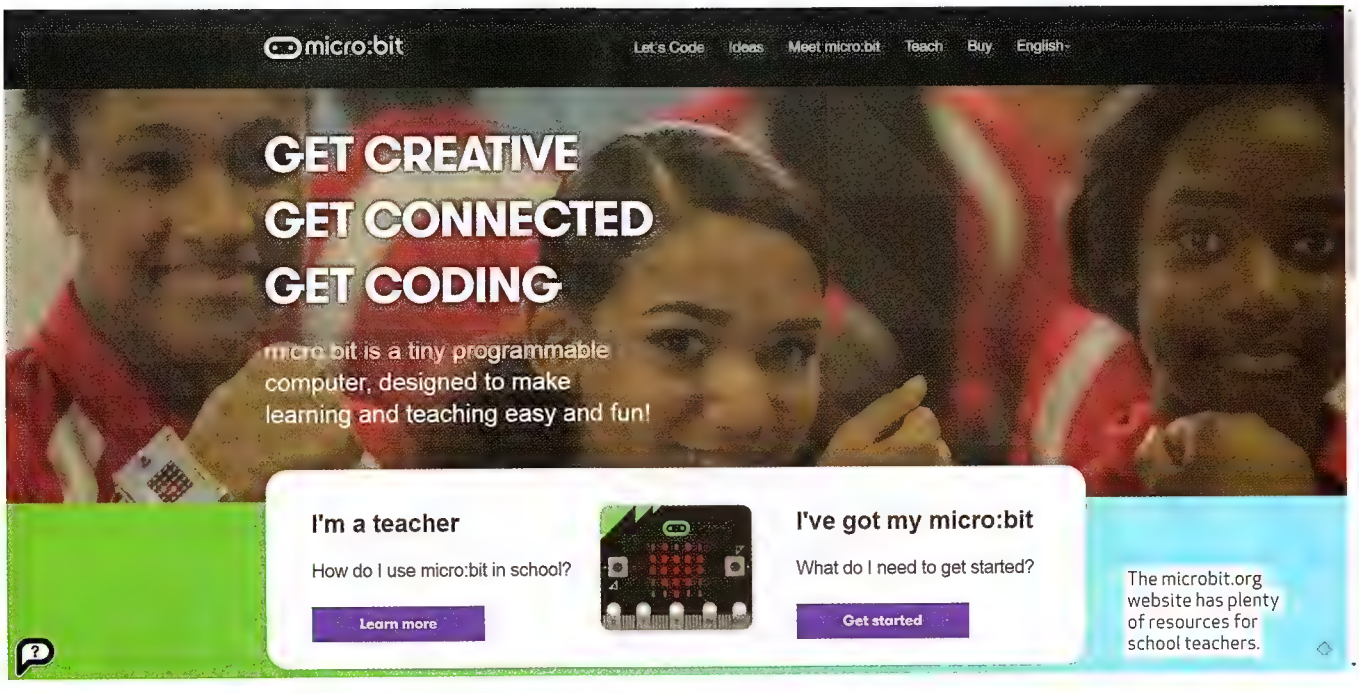
Finally, we set the LED display with the display.set_pixel()command, using the splevelX and splevelY values as the LED X-Y coordinates. The last value in the set_pixel() function sets the LED brightness, from dull (0) to bright (9). Following that, we sleep the code for 100 milliseconds and then clear the display quickly before the loop continues again.

The micro:bit go pack is ideal for schools.

YOUR IMAGINATION IS THE START

Micro:bit isn't the only maker board capable of running Python code directly, but we think it's easier to use than most. That 5x5 LED array is also a great idea – it gives you a low-cost display screen that's still easy to code.

If you're a teacher and you're looking for something to make coding more fun for students Year 5 and up, this is our choice at the moment – it's easy to code, yet gives you the opportunity to put many of the Python basics such as variables, if-conditional statements and loops into practice. It's also loaded with features that require nothing more than adding your own code and a battery pack. Most of all, I love that it's hands-on. When it comes to learning, I'm very much 'old-school' in that getting your hands dirty is generally the best way to learn – and micro:bit lets you do that in a controlled environment that's still lots of fun. Did we mention it uses Python?



The microbit.org website has plenty of resources for school teachers.

downtime games

» EDITED BY CARMEN SEALEY

Combat is far from the focus in *Kingdom Come: Deliverance*.

PC, PS4, XO | $89.95 | WWW.KINGDOMCOMERPG.COM

Kingdom Come: Deliverance

An ambitious, realistic RPG set in mediaeval Bohemia.

The RPG is in rude health, mostly thanks to a burgeoning PC development scene (think *Divinity: Original Sin*, *Pillars of Eternity*) and the genre's prominence among the mainstream (*Fallout*, *The Elder Scrolls*). And yet, most titles tend to stick to fairly rigid archetypes. You've got your fantasy RPGs on the one hand, and on the other, your science-fiction RPGs. Even the latter is rare, and given the style's origins in pen and paper *Dungeons & Dragons*, it makes sense that the fantasy theme should stick so stubbornly.

But *Kingdom Come: Deliverance* is different. It's a purportedly realistic RPG set in 1400s Bohemia. There are no dragons, no spells, no goblins, no staffs. Instead, there's gritty mediaeval poverty, oppressive nobles, violent and trying hand-to-hand combat and... the most pastoral and realistic looking open world seen since *The Witcher 3*. Warhorse Studios crowd-funded this project about four years ago, and while it's definitely got traces of a debut game by an independent studio, it's astonishing just how cohesive and fun this has turned out.

You play as Henry (right), a blacksmith's son. He's not destined to fulfill any prophecy and he's not blessed with some supernatural power. He's just a boring bloke who likes a drink. But when his hometown is burnt and pillaged by the Cumans, he manages to escape and, as a result, endears himself to various regional authorities. He's still a stick-in-the-mud, though, and most of the game is spent carrying out tasks for people with far more power and influence than him.

Warhorse Studios is pretty uncompromising when it comes to the roleplaying element here. You can't grind your levels per se, with the game opting for an *Oblivion*-style progression where you master skills through performing them. One must sleep and eat in order to survive, and in the beginning of the game, combat is slow, arduous and nigh on impossible to win. But all these factors help the player feel more present in the world, and while it's definitely a 'game' rather than a 'sim', *Deliverance* feels like a world rather than a playground.

It's a bit rough around the edges. PC users are experiencing a few technical hiccoughs at launch, though the game runs fine on PS4 Pro. There are glitches aplenty, but the same is true for a Bethesda RPG. One needs to approach *Deliverance* with patience, and open mind, and a willingness to accept its faults. And if you do, you'll find one of the most surprising and powerful games likely to release this year.

■ Shaun Prescott

Verdict

An immersive, challenging and occasionally buggy RPG that panders to the hardcore.

★★★★☆

The twin moons make it clear we're not in Kansas anymore.

PC, PS4, XO | FROM $69.95 | OUTCASTTHEGAME.COM

Outcast: Second Contact

Dimensional rift opens to world of right angles.

Sequels and remakes are the backbone of the modern game industry, the boughs from which the fruits of original creative endeavours can hang. And they have another important function—making great games from the past accessible to those who don't have Windows 98 installed anymore.

17 or so years ago, *Outcast* was cutting-edge, running on an engine that flitted between raycasting for the ground and textured polygons for objects. An enhanced version, *Outcast 1.1*, was released in 2014, but it stuck with the CPU rendering of the original, and was on the blurry side, which is an accusation you can't make of *Second Contact*.

It looks superb, every texture beautifully displayed, every face animating in time to its spoken lines, and the swirling snowflakes of the opening sequence looking soft and featherlike. However, from this fidelity comes the sense that you're playing an old game — everything is very square, the ground very flat, even where it's built up in layers. Mountains jut suddenly out of the surface, nestling plants and crystals at their base, trying to hide the joins. It's all very 1999.

Not that it should matter, as there's a solid game beneath. *Outcast* is a third-person free-roaming adventure game, although the amount of free roaming you can actually do is curtailed by monsters, enemies and quicksand. Humanity has wrenched open a portal to another dimension, and sent through a probe, but it's all gone wrong, and a dimensional vortex now threatens to destroy our world if you don't go through the breach and reclaim Earth's litter. Of course, you get separated from your team, and wake up in a square house, surrounded by beings whose baldness and two-fingered hands must cut down on rendering time nicely.

It's full of charmingly clunky touches, such as the Gaamsaav device you carry in your backpack and use to saav your gaam. We're not sure if the fact the Gaamsaav makes a noise that enemies can hear and will investigate is a stroke of genius or sadism, but it's certainly effective at racking up the tension. Your character looks like an idiot with his gun drawn, as if he's holding it in the very tips of his fingers, which possibly explains why the auto-aim is a bit wobbly, and his reluctance to turn around means running backward is an effective method of withdrawal from suboptimal situations.

Outcast's John-Carter-meets-Jack-O'Neill nature is spread thinly over its structure, the workings of the world are on display, and as you mess with them — disrupting enemy supply lines, for example — you can see its influence on games such as *Assassin's Creed*.

Outcast: Second Contact is interesting as a historical document, sure, but it's still a great game in its own right. Especially now anyone can play it.

■ Ian Evenden

Verdict

A huge adventure with a fine score, although a little clunky here and there.

★★★½☆

Robin's pistol has heat seeking bullets, making combat more breezy in favour of more stressful puzzles.

The Iconoclasts

A narrative-driven platformer brought to life by pixel-perfect art.

PC, PS4, PS VITA | $29.95
WWW.KONJAK.ORG

There's no shortage of pixel-styled 2D platformers out in the wild, but *The Iconoclasts* — developed over eight years by independent Swedish developer Joakim Sandberg — is probably the most beautiful of them all. If you owned a Sega Mega Drive in the '90s, you'll rejoice at its bright, vibrant aesthetic. But such is its detail, and so painstaking is Sandberg's attention to every facet of its artistic direction, that the game more closely resembles one you might have dreamed would release for 16-bit consoles back in the day. Protagonist Robin is a mechanic, though according to the rules of tyrannical authority One Concern, she must undertake the day job *they* delegate. But she's determined to be a mechanic anyway, and this, along with several other story beats, sends her on a quest to foil the powerful oppressor. *The Iconoclasts* is wrapped up in a lengthy (and some might argue, confusing) narrative, with most of its charm derived from Sandberg's environment and character design. The usual 2D rhythm of jumping, puzzle-solving and boss smiting is here, and it's not a very interesting game on a systems level, but it's got a heart of gold and even its imperfections are charming.

■ Shaun Prescott

★★★★½

Dissidia NT Final Fantasy

Living in a Materia world.

PS4 | $99.95
WWW.DISSIDIA FINALFANTASYNT.COM

Remember the charming, slightly lo-fi but somehow impressive *Dissidia* on the PSP? This isn't that. The old *Dissidia* games had RPG elements that bolstered the patchy fighting mechanics and, as such, came to present a more rounded product. *Dissidia NT* lacks any resemblance to an RPG, and instead puts all its effort into being a fighting game. The thing is, it doesn't do that very well either. *Dissidia NT* opts for 3v3 brawls rather than the one-on-one fights of its prequels. These messy encounters often feel unbalanced, and the only tutorial on offer is as dry as they get: there's a slew of mechanics, all working in combat with each other, and often overwhelming. They're presented to you as a reading list of things to learn, making it pretty impenetrable. So you'd think you could just start the story mode and practise in a low-stakes battle. You'd be wrong. The story mode is gated by a collectible item called Materia, which you get via playing in arcade or online. It's a long process, but there's a fairly satisfying fighter underneath, here. With a cast of heroes and villains from every main *Final Fantasy* game, the title is brimming with fan service. The game does a good job of making you experiment and figure out how to play the game. It's just a shame there's such a barrier to entry.

■ Dom Peppiatt

★★★☆☆

apc RECOMMENDS

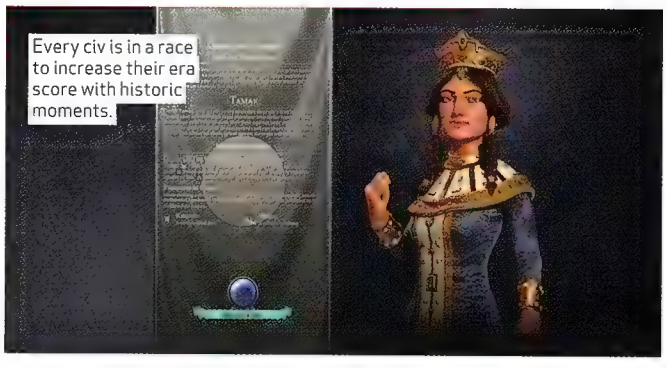
PC | US$30 | WWW.CIVILIZATION.COM

Civilization VI: Rise and Fall

Providing big historical moments and crises.

Continuing the last couple of *Civ* games' predilection for 'unstacking', *Civilization VI: Rise and Fall* has peeled apart more of the series' fundamental systems. This time, it's the march through history itself. It's more dynamic and messy, with civs rising and falling as they enter new eras and experience Golden and Dark Ages. Yet *Civilization* has rarely felt this structured or cohesive.

Eras divide *Civilization*, representing a civ's technological and cultural level. In *Rise and Fall*, the system has been spun out into two types of era: player eras and game eras. Player eras are the mark of a civ's individual progress, while game eras start and end at predetermined moments and affect every civ. The result is that you'll still be rewarded for investing in science and planning ahead, but if you don't, there's going to be a fixed point where the new era officially begins, so you're not going to fall too far behind. It's a nudge towards parity that keeps things interesting without diminishing the rewards.



Every civ is in a race to increase their era score with historic moments.

It's with the inclusion of Golden and Dark Ages that things get a bit messier. A Dark Age introduces new challenges. If you've not expanded too quickly and your cities are pretty loyal, then you'll likely make it through unscathed. If you've done well and gathered enough era points during the Dark Age, you'll enter a Heroic Age.

Large-scale international emergencies are new co-op events that task civs with banding together to solve a crisis, targeting another empire.

While the objectives are simple and the AI isn't a great team player, it's an effective way to force civs into conflicts, making the world a bit livelier in the process. Perhaps more importantly, it turns what could have been overlooked moments into significant events. We wouldn't have remembered these crises in any other game, honestly.

That's what lies at the core of *Rise and Fall*. It's an expansion that homes in on single moments or periods and gives them greater impact. It shakes things up, so it won't convert everyone, but the added dynamism is a massive boon for a series where the pace can be predictable. ■ Fraser Brown

Verdict

A tumultuous expansion that finally introduces golf to *Civilization*.

★★★★☆

apc HOT PRODUCT

PC, XO (PS4, COMING SOON) | $27 | WWW.UNKNOWNWORLDS.COM/SUBNAUTICA

Subnautica

Everything's better down where it's wetter.

The basic premise of *Subnautica* is that you have crash-landed on an alien planet. You can see the burning hull of your ship, the Aurora, from your life pod. You seem to be the sole survivour, and you have no idea what lurks beyond the shallows.

The first order of business is basic survival, so you investigate the vibrant sea outside your pod, seeking out the resources your fabricator needs to craft food, water and essential tools. You'll break open lumps of lime and sandstone to find deposits of titanium, silver, lead and more. A pillowy-looking fish is useful for water filtration, while others are good eatin'. There are gigantic coral tubes, shoals of boomerang fish, huddles of docile creatures with long noses and glowing bums, and clusters of neon plant life.

Once you've familiarised yourself with the basics, you find yourself able to venture further and survive longer. *Subnautica* meets this increased confidence with beautiful biomes, tempting you with new resources and new creatures.

As you poke around, you start to flesh out the story beyond your own immediate survival exploits. Some of that comes via exploration and some is via audio snippets which your radio will pick up. How you choose to balance pursuit of the narrative against pottering under the sea is up to you in the main Survival mode. But Creative mode strips out all the survival and the story, just letting you build and explore. Hardcore gives you only one life and no oxygen warnings.

Even though we were trying to focus on the story, we kept defaulting to a lovely, restful flow between three things: building up a habitat; exploring different zones; and then pursuing the narrative. That's not great time management for a review, but it's a great quality in the game itself.

Undersea exploration isn't everyone's cup of tea, but we find sea life fascinating. In *Subnautica*, each biome is infused with its own distinct combination of alien and familiar beauty. We love exploring their caves and crevices, and following the creatures around – even the more aggressive ones – with a scanner in hand. Each successful scan rewards you with new facts about life on this ocean world.

The worst thing that can happen is you lose a bit of progress when you die in a cave system, or you get a jump scare thanks to an aggressive creature swimming up behind you. And something in the deep water destroyed our little submersible in an instant...!

Habitat-building can be a bit finicky, and there are a few irritants to be found along the way (glitches can be costly), and a more flexible save system would have been useful.

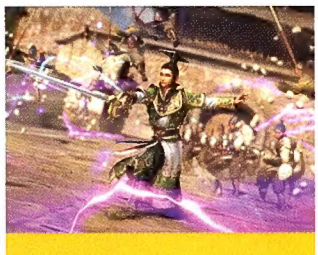
We really enjoyed how the story unfolded and the game lets you engage with it as much as you choose. The main arc was compelling, with some lovely emotional moments. And we are still playing it... 120 hours in.

■ Philippa Warr

Verdict

A smattering of technical issues keep it from true legendary status at launch, but only just.

★★★★½



Dynasty Warriors 9

Far bigger, but not necessarily better.

PS4 | US$10
KOEITECMOAMERICA.COM

The liberal use of artistic licence and anachronism, the eclectic soundtrack combining traditional instruments with cheesy rock goodness, the return of the one-man army: *Dynasty Warriors* is back! But the ninth instalment adds a few new steps to the tried-and-true routine of previous entries, going open world for the first time, among other things. Once again, grand-scale military battles form much of the backdrop as your chosen champion of the three rival states takes centre stage. Between mashing basic combo attacks and interjecting with special Musou moves, *DW9* stuffs a few more tricks up your sleeve, such as counters, finishing moves, a guard break, knock down or even launch your enemies into the air. Gems can be forged into your weapons, adding welcome variety and an additional layer of visual flair to combat. Boasting a roster of over 80 characters, the amount of content is impressive. Tucked into every corner of the expansive map are stunning vistas plus a number of new additions, including hideaways you can buy and kit out, and watchtowers that let you push back the fog of war. But despite everything, the open world still ends up feeling empty, even the settlements feel lifeless.

■ Jess Kinghorn

★★★☆☆

Musk's Boring flamethrowers sell out

Fundraising prank brings in serious money.

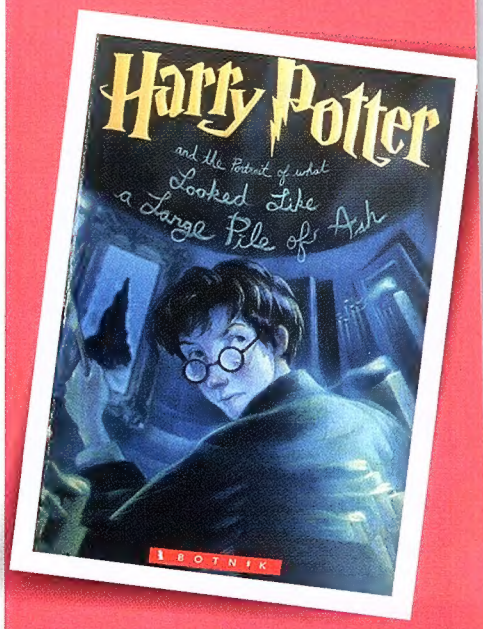
Mid December last year, Elon Musk – our saviour and future overlord – was busy selling US$20 baseball caps in an effort to raise money for the "soul-destroying traffic"-avoiding tunnel business he spontaneously created in 2016: The Boring Company. And since this is Elon Musk we're talking about, he promised to then start selling flamethrowers if all 50,000 hats were sold, which they inevitably were. In a promotional video, Musk said, "I want to be clear that a flamethrower is a super terrible idea. Definitely don't buy one. Unless you like fun." And because Americans and the internet exist, it's no surprise that the whole 20,000 stock of Boring Company flamethrowers (at US$500 a piece) were sold out, netting the company an easy US$10 million. It's small comfort that these weapons of 'fun' at least came with complimentary fire extinguishers...

Elon Musk @elonmusk 28 Jan
The rumor that I'm secretly creating a zombie apocalypse to generate demand for flamethrowers is completely false
Elon Musk
@elonmusk
You'd need millions of zombies for a so-called "apocalypse" anyway. Where would I even get a factory big enough to make so many!?
5:40 PM - Jan 28, 2018
122K 21.6K people are talking about this

Taiwanese police accidentally give out malware-infected USB drives

AS PRIZES FOR EXCELLING IN A SECURITY QUIZ.

Late last year, the Criminal Investigation Bureau (CIB) in Taiwan hosted a cybersecurity quiz and gave out 250 USB drives as prizes to those who did well. According to following reports, 54 of these 8GB drives were inadvertently infected with malware designed to steal personal data from 32-bit machines. The infection was supposedly an old virus, however, and the CIB has reported that the stolen data was forwarded to an IP address in Poland that is no longer up and running. Still, there are a number of drives that haven't yet been accounted for, so a few prize-winners might have a nasty surprise waiting for them... Good thing they know a thing or two about cybersecurity!



The bot that's channeling JK Rowling

ACCIO... AUGMENTED CONTENT CREATION!

"Not so handsome now," thought Harry as he dipped Hermione in hot sauce. The Death Eaters were dead now, and Harry was hungrier than he had ever been.

No, that's not an excerpt from some horrible teen-written *Harry Potter* fan fiction. This is the work of Botnik, a group of four writers, artists and developers "building and using machine tools to remix and transform language". By inputting source material (in this case, the *Harry Potter* books and fragments from the community), they've conjured up *Harry Potter and the Portrait of what Looked Like a Large Pile of Ash*. We recommend reading the excerpts on the website, even if you're not a Pothead: **botnik.org/content/harry-potter.html**

Russian interference in election nominated for ad awards

MANIPULATION GONG.

The New Yorker reported in early February this year that a few members of the ad industry had created a campaign to "give Russian hackers proper credit" for their efforts in affecting the results of the 2016 American election. Recognising that the accused Russians "didn't have huge budgets" and that their campaign had made a 'disruptive' impact on the election, they decided that they would put together a fake Webbys submission on their behalf. However, as production continued, one of the creatives involved decided to go the whole hog and submit officially. One of the aims was to raise awareness about the power of advertising "when those powers fall into the wrong hands". You can see their amusing, yet stark nomination video here: **www.projectmeddle.org**

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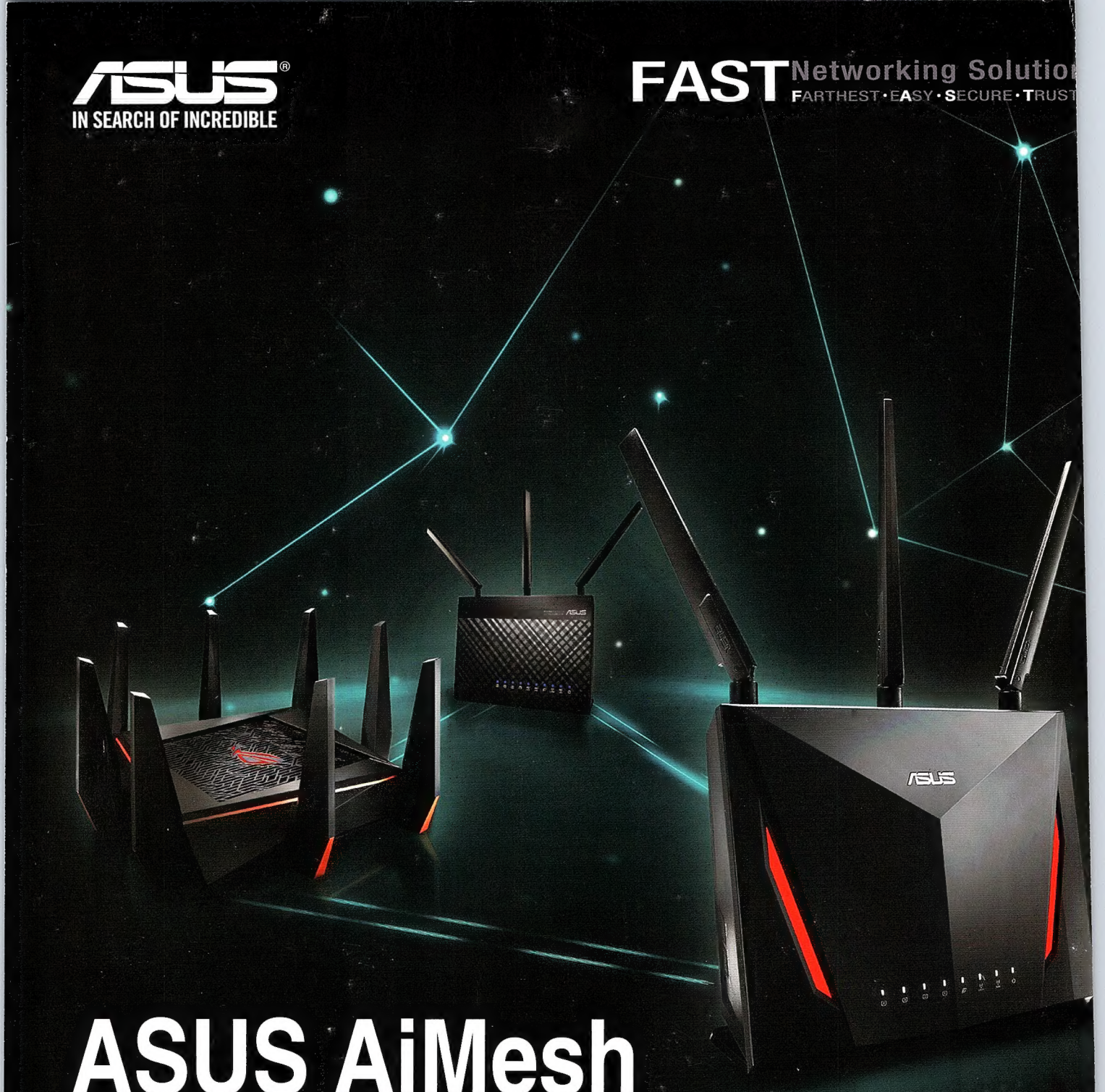

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